FAUNAL ANALYSIS OF THE SANDERSON SITE (DhMs-12), BLOCK SEVEN WEST

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by
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ABSTRACT

The Sanderson site (DhMs-12) is a Mortlach phase faunal processing area located on the Souris River in southeastern Saskatchewan. The site is composed of two occupation levels separated by a sterile layer. The upper level of the site is dated to approximately 250 years ago. The site is located within a riverine ecotone, similar in location to other Mortlach sites from Saskatchewan, North Dakota, and Montana.

Excavations were carried out by the Saskatchewan Research Council in order to salvage the site as part of the Rafferty Hydroelectric Dam mitigation project. The excavation area labeled as Block seven west was used as a sample for the faunal analysis of the site and yielded material with excellent preservation but high levels of fragmentation. There were a number of different animal species represented at the site although bison were predominant. A detailed faunal analysis was undertaken to determine the composition of the bison herd and canid species identification. The faunal material was also analyzed in order to determine the seasonality and taphonomic history of the site.

An actualistic study was designed to determine the effects of freezing on bone breakage. This was done to examine the effects of seasonality on butchering practices. The study indicated that the biomechanical nature of the bone was altered by freezing resulting in a visibly different breakage pattern.

The Sanderson site represents a Late Prehistoric Period and the level of bone destruction is typical of the heavy processing of bone for grease that occurred during this time period. The extreme level of this destruction is atypical and may indicate a butchery activity that occurred during the colder winter months.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In the 1986, the Saskatchewan Research Council began an archaeological survey and mitigation program along the Souris River Basin in southeastern Saskatchewan in preparation for the construction of the Rafferty Dam. The Sanderson site (DhMs-12), a Mortlach kill/butchering site, was one of many sites uncovered during the course of the filed reconnaisance. Roy Sanderson of Estevan initially brought the site to the attention of the Saskatchewan Research Council archaeologists working on the project. The site had been initially exposed when the dam at McDonald Lake was breached in the 1940s (Sanderson pers. comm.). Mr. Sanderson noticed bison bone brought to the surface by cattle trampling at the edge of McDonald Lake. The site was located at the bottom of the north-facing slope of Muirhead's hogsback in one of the few wooded areas of the region. The site had not been previously cultivated but had been impacted by annual flooding along the river.

The location of the Sanderson site indicated that it would be affected by innundation when the dam reservoir was filled and the construction of the dam and spillway downriver from the site. This required that the Sanderson site and a number of other sites located nearby be adequately assessed and the impacts mitigated. The testing of the Sanderson site indicated an extensive intact occupation. Based on these findings a large salvage excavation was undertaken that uncovered an extensive bone bed, pottery shards, lithic debitage and tools, and European trade goods. The cultural affiliation of the

site, based on the pottery, indicated an association with the Mortlach phase. Based on radiocarbon dates for the upper levels of the excavation the site occupation was at least 300 years old. or dated to A.D. 1650.

In total, 211 m^2 were excavated in the form of ten block excavations. Forty-eight m^2 of this sample were used in this study for faunal analysis, representing the western portion of block 7; the largest block in the excavations. The physical condition of the bone was generally fragmented although surface preservation was excellent.

In order to evaluate the faunal material there were a number of research goals were established. The first objective was the accurate identification of the faunal material from the site. This allowed interpretations about the subsistence strategies used at the site. Second, the distribution of the faunal material was analyzed in order to determine any patterns that occurred within the site itself. Third, there were multiple sources of information from the faunal and paleobotanical material at the site that were used to identify the season of occupation. Fourth, the canid material at the site was the largest collection recovered in the province of Saskatchewan to date. The number of cranial remains from the larger canids allowed a detailed analysis to determine their species affiliation. Fifth, the preservation of the material allows an assessment of the types of taphonomic forces that affected the faunal assemblage and the degree to which these forces altered the assemblage. Sixth, the faunal material had good enough surface preservation to provide an opportunity to examine at the butchery patterns and utilization of the faunal material. Seventh, the degree of fragmentation that was seen in the Sanderson site faunal assemblage is extreme and a middle range study was undertaken to explain this phenomenon. The Block 7 west sample only has 3.8% identifiable bone and

this is comparable to the other block units at the site. Such low identifiability is mainly a result of fragmentation, including an unusual patterns of breakage in the carpals and tarsals, bones of extremely low nutritional value that are embedded in a protective sheath of ligaments and retinacular tissue. Fractured tarsals were described at the Harder site (Morlan 1994a:773), an Oxbow habitation site. The Harder site fracture patterns were hypothesized to be the result of intentional destruction of the bone, but rather ancillary damage caused by the butchering of frozen limbs. In order to test this hypothesis an experiment was undertaken to evaluate the effects of freezing on bone breakage patterns.

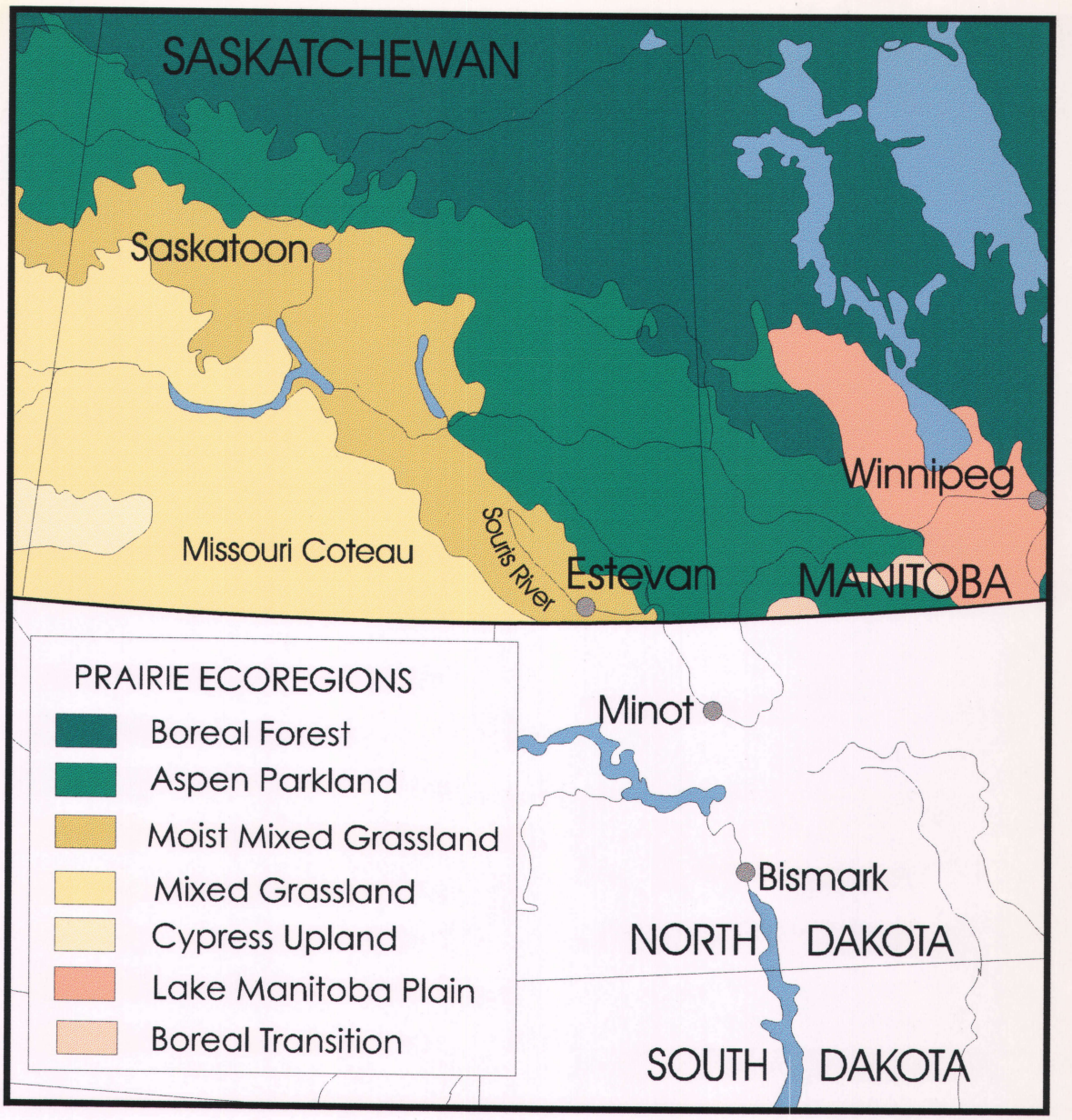
CHAPTER 2

BACKGROUND

2.1 Natural Setting

The Souris River basin is part of the Saskatchewan Plain which stretches from the Missouri Coteau of the Alberta Plain in the west, to the Upper Assiniboine Delta lying just west of the Manitoba Plain in the east (Figure 2.1). The Souris River basin in Saskatchewan is characterized by gently rolling plains and hummocky areas. The plains are incised by the valleys of the Souris River and its tributaries. The main river valley is a glacial melt water channel averaging about 30 meters in depth. The river channel itself has a depth varying from 1.5 meters to 7.6 meters (Souris Basin Development Authority 1990:21).

The Souris River basin is classified as a Valley Complex ecotone and is flanked by both the Moist Mixed Grassland and further down river the Aspen Parkland ecotones. Due to a generally higher level of moisture in the small valley and coulees, there is a much wider range of plant and animal resources than in the surrounding area. Plant and animal diversity approaches that of the parklands rather than the grasslands adjacent to the Sanderson site. The richness of the area is also due to the close proximity of a number of different resources along the borders of the different ecozones of the area. It is recognized that "edge effect" is the result of the border between two distinctive vegetation types where the variety and density of resources results in an increased relative abundance of wildlife (Sekgororoane & Dilworth 1995:1432). This increased abundance is true of a number of animal species including rodents and the animals who feed on



them. The Sanderson site has grassland, forest, marsh and riverine ecotones bordering one another within one kilometer of the site making it extremely attractive to wildlife.

The limiting factor in the valley complexes is the extreme spatial restriction. This would result in a depletion of resources quite quickly by resident human populations. Although it would not be possible to live in the restricted areas of the valley complexes

round annual migrations out of the area in the spring would allow the resource base to recover.

2.2 Climate

This area of the Souris River basin is in a continental climatic zone, ranging from semiarid in the west to subhumid in the east. Temperatures often fluctuate between years but as an indicator of seasonal temperatures there are on average 175 days with a mean temperature above 5.55 degrees Celsius. This time period, defined as the growing season, extends from late April to mid-October. On average, the frost free period lasts about 100 days, from the end of May to the first week in September (Souris Basin Development Authority 1990:22).

2.3 Hydrology

The Souris River is classified as sinuous meandering channel. Characteristically point bars are created by deposition along the inside of the river bends. The duration of the meandering behaviour has resulted in a complex meander belt being formed on the floodplain below the Sanderson site.

Like other prairie streams, rate of flow in the Souris River are highly variable. One yearly constant is that eighty percent of the annual riverflow occurs in spring during snowmelt from March to the end of May (Souris Basin Development Authority 1990:27). The Souris River in the area of the Sanderson site has its peak streamflow in the month of April (Souris Basin Development Authority 1987a:37) even though the peak for rainfall occurs in June (Souris Basin Development Authority 1987a:30). The high flow is therefore due to a generalized increase in water volume caused by melting snow and ice

rather than an increase in precipitation. This has resulted in a flood history that is both intermittent and variable in intensity but predictable in temporal occurrence.

During these periods the river would have had a tremendous increase in sediment load. Usually sampling a river during flood periods will give an indication of approximately 90 percent of the yearly load carried by that river (Kazmann 1972:83). The highest sediment load recorded during this time period was an extreme of 7,910 t/d (tonne/day) recorded during the Souris River flooding of 1976 (Souris Basin Development Authority 1987b:37).

The effects on the Sanderson site would be irregular annual flooding. Deposition at the site would likely occur in the month of April. The level of the flooding during this period would depend on the increase of flow. Table 2.1 gives an indication of the expected increase in water levels based on flooding estimates done at Estevan, Saskatchewan approximately 9 kilometers downriver. It should be noted that estimated 1 day flood peaks for 1:100 floods are comparable between Estevan and the adjacent McDonald Lake region, next to the Sanderson site (Abrahamson & Martin 1977:60).

Table 2.1 Water elevation levels at Estevan under various flood conditions

Flood Type	Water Elevation (m)
1:25	1775
1:50	1785
1:100	1793
1:500	1800

Based on these elevations the site will likely be innundated during 1:100 and 1:500 flood events, meaning the site will experience flooding during 100 year intervals and major flooding at 500 year intervals. Figure 2.2 is a reconstruction of the site under normal conditions while figure 2.3 is a reconstruction of the site under flooding

Figure 2.2 Sanderson site area under normal conditions

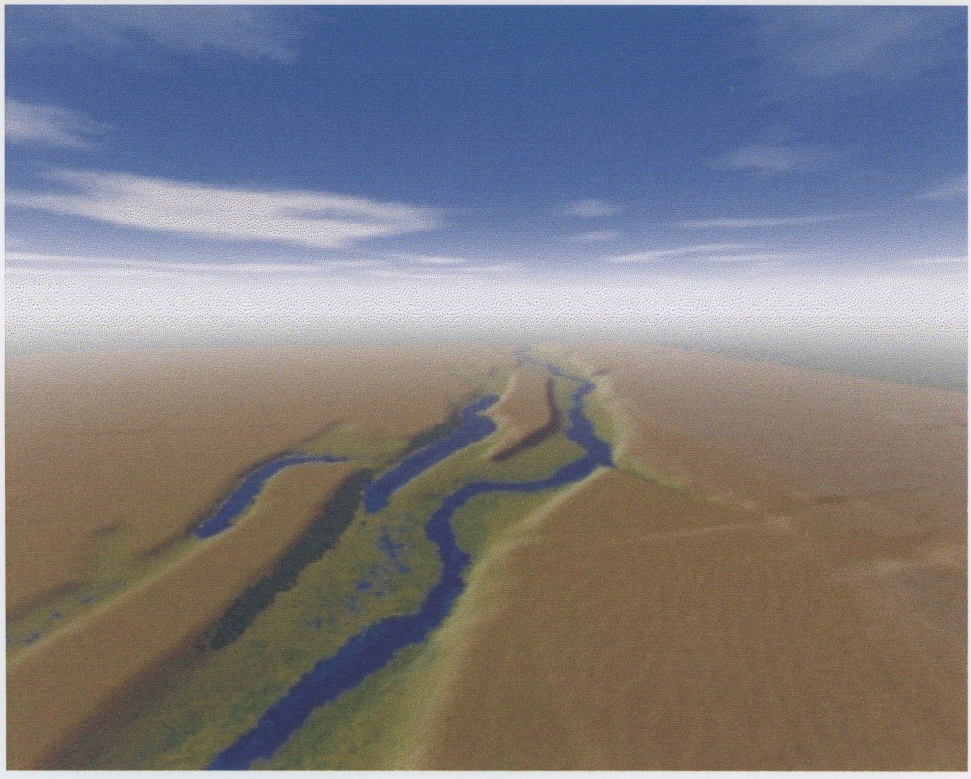
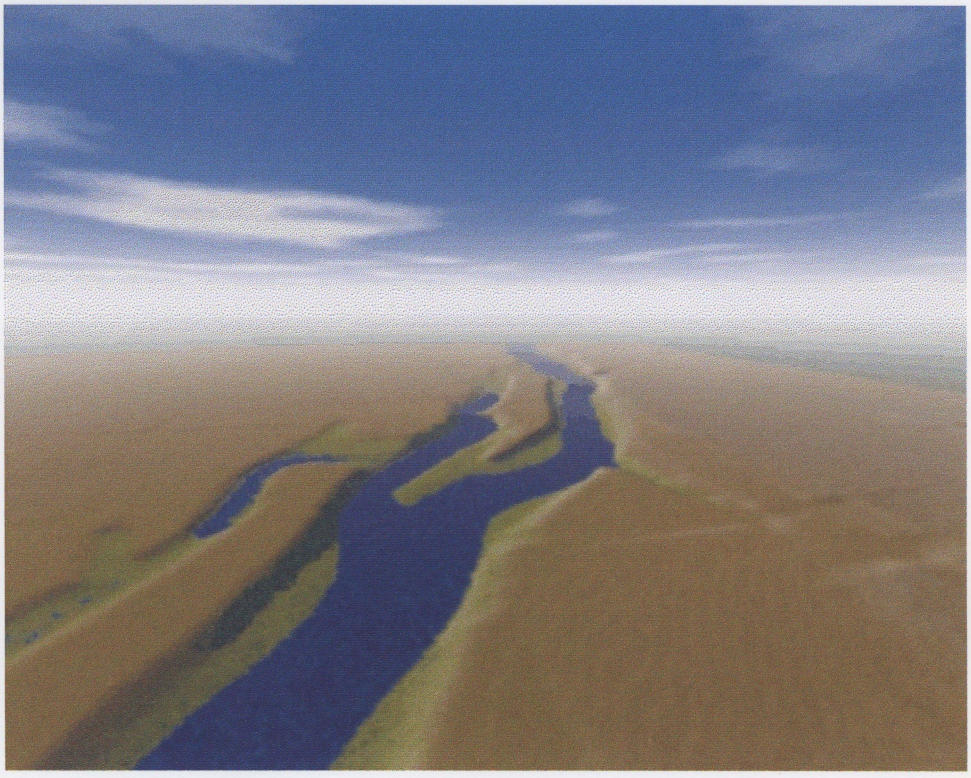


Figure 2.3 Sanderson site area under 1:100 flooding conditions



conditions. The relatively steep walls of the river valley in this region prevents the river from expanding out onto the surrounding prairie. This has the effect of keeping the flow rate relatively high until the river valley widens downstream in the Estevan region.

The current effects on the site are entirely different since the existence of a dam has created an artificial reservoir. This reservoir had not fully covered the site in 1995 as seen in figure 2.4. It will not be until the reservoir is completely filled that the site will be totally underwater (figure 2.5). The erosional damage to the site caused by the reservoir has not been evaluated and therefore the current state of the site is difficult to estimate.

2.4 Sedimentology

The sedimentology at the Sanderson site is almost exclusively dependent on the behavior of the Souris River although slope wash could affect the site from the period of snow melt to late in the Fall when precipitation has turned into snow. As noted in the hydrology section, most of the fluvial deposition at the site occurs during the month of April.

The bottom of the Sanderson site excavation (25 to 30 cm) contains mostly sand and gravel (Figure 4.6, 4.7). Heavy sediments of this kind are the result of recent activity of a heavily flooded river which would have held a large sediment load. They could not have been deposited by the glacial river as cultural deposits were located at a depth of 80 cm. The next level of deposit sediments in both the upper and lower occupation levels were classified as silty loam. It is unlikely that they are the result of stream deposition as there are no crevasse channels located near the site. It is more consistent with riverine deposits, the speed of the river maintaining enough kinetic energy to hold the finer grains. The site location is not on the floodplain so the deposition is not the result of migration of

Figure 2.4 Sanderson site area under low reservoir conditions

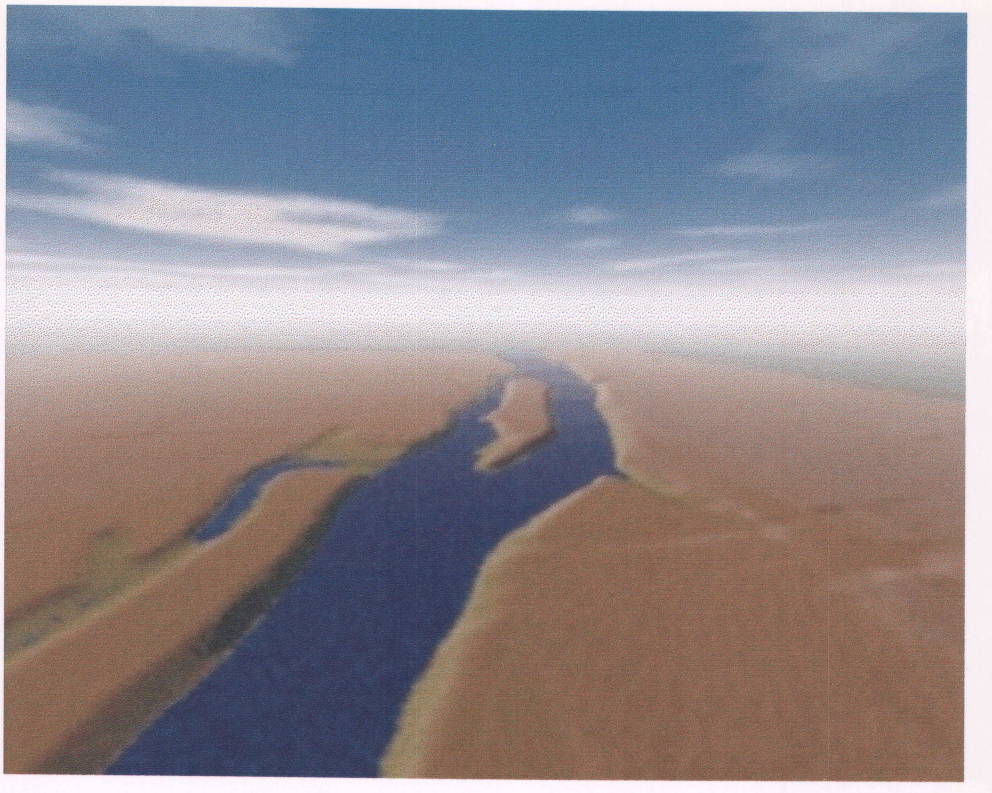
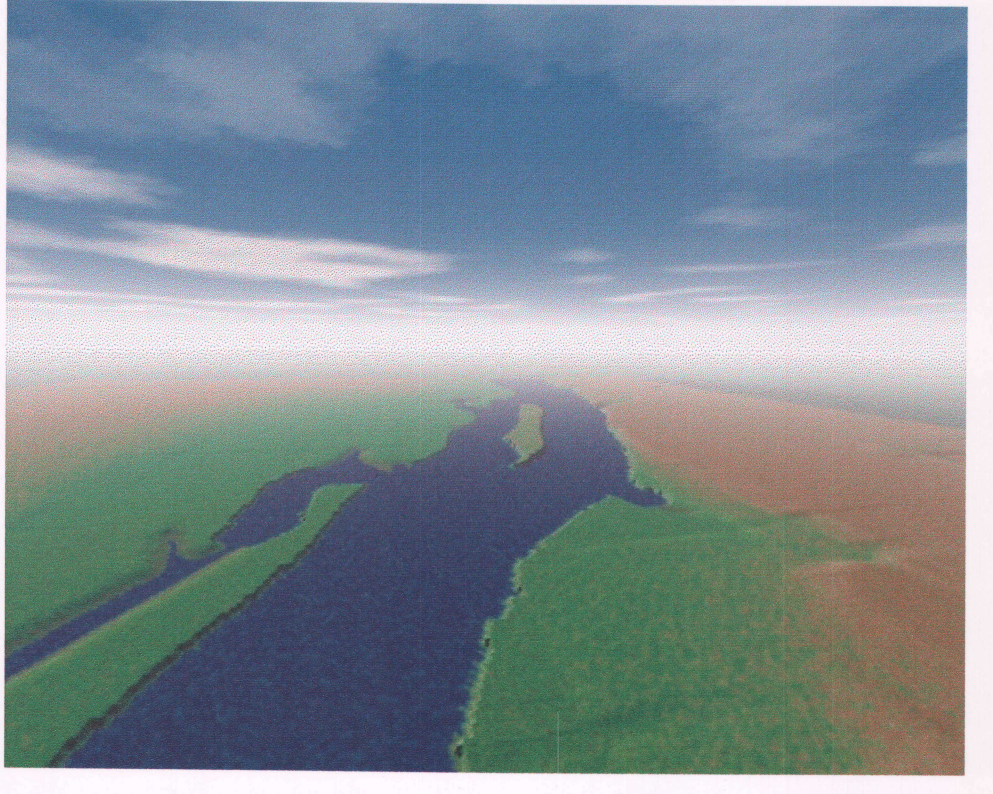


Figure 2.5 Sanderson site area under full reservoir conditions



the main channel body over the site. There is also a lack of any structural evidence of a river bed which would leave an indication of channel bodies and differential deposition. It is more likely that the deposits occurred during a flooding event in the past. Overbank flooding would have resulted in a sheet flood filling the river valley. Deceleration of the floodwater would have occurred as distance increased from the channel margin. This would have resulted in deposition of progressively finer sediment towards the edges of the floodwater (Leeder 1982:144). The silt would have then have been deposited at the margins of the flood, where the velocity of the water had decreased enough to drop its sediment load.

The layer of sterile gray clay found at a depth of 15 to 20 cm is unusual for the site. It is more consistent with some kind of alluvial rather than fluvial deposit. There are a number of possibilities for the creation of this layer at the site. Overbank flooding may have created a sheet flood which filled the river valley. The decreased velocity of the floodwater at its edges would have allowed the finer clay sediment to drop out and create the layer. The lack of large silt particles in the layer may be related to variability in discharge rates from year to year. The heavier particles could have been deposited closer to the main river channel. There is also the possibility of an alluvial ridge being formed by river meander migration or levee creation during flooding (Leeder 1982:145). These structures stand above the topography of the floodplain. If the Souris River itself did not create the structure the stream flow from McDonald Lake entering the flooded Souris River could have. A similar phenomenon occurred at the Long Creek site eight kilometres downstream (Wettlauffer and Mayer-Oakes 1960:12). During heavy flooding the stream flow tends to lose its sediment when it hits the already sediment laden Souris

River. This results in the creation of a levee as the stream bed increases in level. The local damming effect creates a small lake that may last well into the summer but does not usually survive the next yearly flooding. It is also possible that the layer is a continuation of a fining upward sequence that occurred as occupation two was buried. The size of the sediment particles being deposited would decrease as the river flow slowed. This kind of phenomenon could occur naturally during an ice jam or any of the previously mentioned damming events (figure 2.4).

2.5 Flora

Due to the extensive agricultural development that occurred when European settlers moved into the area it is necessary to do a historical review of the vegetation around the Sanderson site. The terrain mainly consisted of open native prairie supported by dark brown and black chernozemic soils (Souris Basin Development Authority 1987d:6). The occurrence of frequent prairie fires in the area restricted woody vegetation to the slopes and bottoms of river valleys and the moist soil of coulees and drainages. Most shrubbery and tree cover was therefore restricted to these sheltered areas (Souris Basin Development Authority 1987d:6).

Changes arose with the arrival of European settlers who brought about agricultural development that controlled and restricted prairie fires. This, and the loss of grazing pressures with the extirpation of the bison (*Bison bison*), led to denser vegetation and more soil moisture conservation. This new environment encouraged the invasion of more mesic species of plants, giving the area its modern appearance, much different from a hundred years ago (Souris Basin Development Authority 1987d:7).

The modern vegetation at the Sanderson site is within the intermediate floodplain community above the frequently flooded lower floodplain. The area around the site is dominated by tall shrubs such as saskatoon berry (*Amelanchier alnifolia*) and chokecherry (*Prunus virginiana*). Manitoba maple (*Acer negundo*) forms a significant overstory while Green ash (*Fraxinus pennsylvanica*) forms an understory of younger trees (Souris Basin Development Authority 1987c:11). Most of the vegetation in the area is on the north facing slopes. This modern vegetation type is not the result of modern intervention as the location of a permanent water source nearby and the recovery of chokecherry seeds from the deeper levels of the site are a good indication that the moisture loving vegetation survived both bison grazing and prairie fires in prehistoric times.

2.6 Fauna

There were a number of wildlife surveys conducted as part of the environmental assessment of the Rafferty Dam reservoir. This resulted in modern, accurate counts of the mammalian, avian, piscine and reptilian fauna that inhabit the area to supplement the information from established literary sources.

2.6.1 Mammalian

Prior to the mid 1800s, most wildlife was unaffected by European settlement. After that time period the fur trade and land settlement had a permanent affect on some animal populations. Despite this the diversity of resources in the McDonald Lake region still attracts a variety of mammals both seasonally and year-round. In order to provide a complete species, list information was synthesized from a modern wildlife survey (Young & Ludwig 1988), and literary sources, Banfield (1987), Maher (1969), and Burt (1964).

There were five species listed within the Order Artiodactyla including the mule deer, white-tailed deer, elk, pronghorn and bison (Appendix I,Table 1). Only the mule deer and the white-tailed deer still exist in the area today. It should be noted that white-tailed deer may have only been a recent appearance in the area after the advent of European road construction and agriculture. Mule deer have had a longer time depth in the area and are attracted by the mixedwood forests stands along the river valleys. They were noted in the 1987 wildlife survey but their abundance was not recorded (Young & Ludwing 1987). There were also numerous herds of pronghorn which are considered extirpated in the area today. This may not be entirely accurate as small herds were noted in the area during the wildlife survey (Young & Ludwing 1987). The other two ungulates, bison and elk both disappeared from the area after European agriculture and overhunting began.

There are an abundance of carnivores in the region, at least eighteen have been recorded for the region (Appendix I,Table 1). The most economically important were the canids which include the swift fox, the red fox, the coyote, and the wolf. Only the red fox and the coyote still exist in the region today. The swift fox and the wolf were commonly hunted by native groups in the area and have been recovered from a number of archaeological sites. The wolf likely represents *Canis lupus nubilis*, a prairie wolf which became extinct when its chief food source, the bison, disappeared.

A large number of rodents are attracted to the McDonald Lake region (Appendix I,Table 1). Beaver and muskrat find good habitat on McDonald Lake due to stable water levels, waters of sufficient depth to allow overwintering, stable and fine-texture bank soils for den construction, deciduous vegetation for food and lodge-building in close

proximity to water and a wetland mosaic terrain for maximum habitat availability (Yound and Ludwig 1988:30). Some of these animals were prized for their economic importance. Beavers were a valued food item due to their high fat content and fur. Porcupines also appear in the area and were sought after. They are slow moving animal which could be easily dispatched, providing meat for food and quills used in decoration.

The large number of smaller rodents and microtine rodents were attracted to the area by the abundant food and shelter provided by the regional flora. There are 14 different species that inhabit the area including the deer mouse, Richardson's ground squirrel, thirteen-lined ground squirrel, prairie vole and meadow vole. Some of these animals may have had economic importance as a protein source in the past.

2.6.2 Avian

There are a number of species of birds that inhabit the McDonald Lake area. The wildlife study of the area focused almost exclusively on migratory waterfowl but there are a large number of other avian species in the area. Table 2, Appendix I contains a species list that is a synthesis of the wildlife study (Young & Ludwing 1987) and other literary sources (Godfrey 1986). The list is not exhaustive as the inclusion of many of the smaller birds of limited economic importance would have been irrelevant to this study.

The Sanderson site lies within the Mississippi, Central and Atlantic flyways (Hawkins 1984). Therefore it occupies a major corridor for migrant and breeding birds (Bellrose 1976; Linduska 1964). The area around the Sanderson site is defined as "Grassland", using the classification of Bellrose (1979), an ecoregion well known for its waterfowl reproduction and staging capability (Bellrose 1976, 1979). The Canada Land Inventory capability for waterfowl production defines the land along the Souris River in

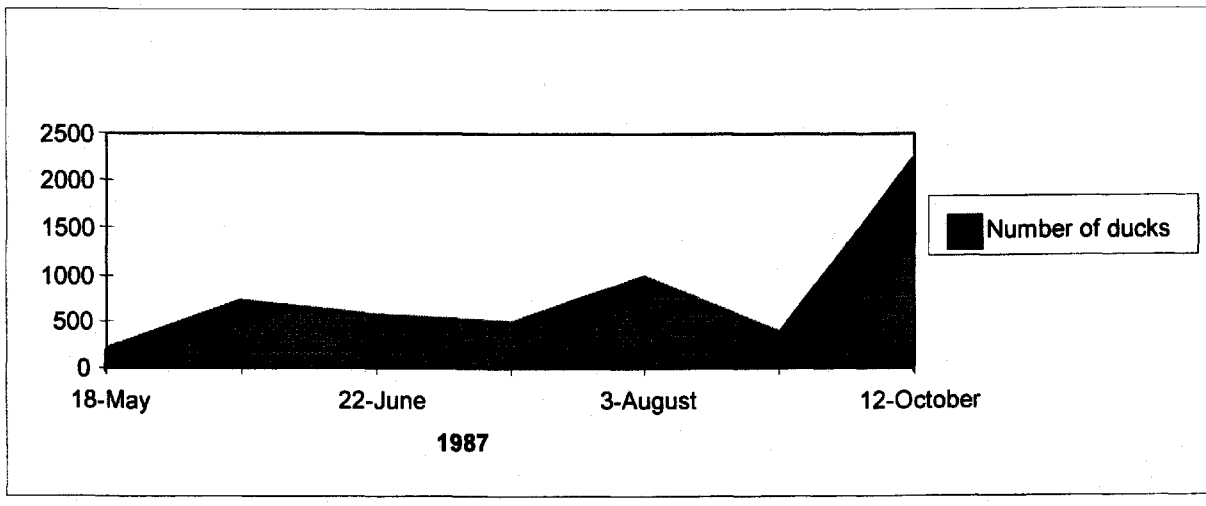
the area of the Sanderson site as Class 5, considered to be low quality habitat for waterfowl and having restrictions to waterfowl production. The presence of McDonald Lake provides the largest attraction for waterfowl rather than the Souris River itself.

Typical migratory behavior of waterfowl place their arrival during April and early May. Preferred breeding habitats include the wetland habitat surrounding the McDonald Lake region. The area also maintains a fairly large number of birds follwing the breeding season (Figure 2.7 and Table 2.2). The large surge in population in the late summer coincides with the build up of flocks prior to migration back south. The McDonald Lake region seems to be a focal area for such build-ups. The variety of species found in the area during the 1987 wildlife investigations are included in table 2.2.

Table 2.2 Adult Waterfowl in the McDonald Lake area(Young &Ludwig 1988:21-23)

Species	Total (1987):	Spring	Summer	Fall
Wood Duck	2	2	-	-
Green-winged Teal	9	2	7	-
American Black Duck	1	1	-	-
Mallard	3635	460	797	2378
Northern Pintail	106	1	88	17
Blue-winged Teal	275	49	196	30
Northern Shoveler	23	14	9	-
Gadwall	1071	179	746	146
American Wigeon	347	107	187	53
Canvasback	127	79	25	23
Redhead	59	28	25	6
Lesser Scaup	77	43	6	28
Common Merganser	1	1	-	-
Ruddy Duck	37	24	12	1
Canada Goose	738	31	52	655
Tundra Swan	31	-	-	31
Snow Goose	3050	-	-	3050
Ross' Goose	1	-	-	1

Figure 2.6 Summary of Adult Duck Occurrence, McDonald Lake.



Mallard and Gadwall dabbling duck species seem to be the most common throughout the season but there is also a considerable boost in the goose population in the late fall.

2.6.3 Reptilian and Amphibian

The wetland and aquatic environments around the Sanderson site are the habitats of a number of different species of reptiles and amphibians. The winter temperatures in the southeast of Saskatchewan are warmer than other parts of the province. This is essential for the survival of these animals during hibernation. A list of the reptiles and amphibians in the area is included in Table 3, Appendix I. This is a summary of the literary sources Stebbins (1966) and Maher (1969). Most of the reptiles and amphibians are of limited economic importance in the subsistence strategies of the region although some of the turtle species provided material for ornamentation and meat for food.

2.6.4 Piscine

The river both upstream and downstream of the Sanderson site is a low gradient system that has resulted in a meandering channel and a surrounding marsh This has

created an area well suited to the spawning and rearing habitat for Northern Pike. There are also suitable spawning areas for Yellow Perch, Black Bullheads, Fathead Minnows and Brook Sticklebacks. Suitable spawning areas for White Suckers are rare and this fish is not often found in this river segment (Fernet 1988:24). A complete list of fish available in this section of the river is given in Table 4 of Appendix I and is based on the fish study of the area by Fernet (1988) and the literary sources of Atton (1969) and Page & Burr (1991).

2.7 Site Reconstruction

All of the illustrations of the site are based on a computer generated DEM (Digital Elevation Model) created from existing 1:50 000 flat map elevation data. The DEMs were translated into VistaPro 3.0 by Romtech industries, a software package that allows the manipulation of vegetation patterns and water levels within a digital model and can create perspective views of the results. It is a site scale micromodel under the definition of Dincauze (1987:270). This means the reconstruction is meant only to recreate the site and its immediate environment and not look at larger scale continental factors. The model was created to perform a number of functions in the analysis of the site including landform reconstruction, floral reconstruction, and flooding behaviour at the site. Site reconstructions should not be undertaken purely for the sake of themselves, they need to have some purpose in reconstructing the past environment in order to understand the site influence on the behaviour of past cultures. In the case of the Sanderson site the flooding behaviour of the site affected the time period of occupation possible throughout the year and the existence of the marshlands, forest and nearby lake at the site in prehistoric times affected the faunal and floral resources available. In more modern times the effects of

dam construction and the formation of a reservoir downstream of the site can be investigated in terms of site innudation and erosion.

The validity of any model created of an ancient landscape is always open to questions of interpretation. The existence of paleoenvironmental evidence in the zooarchaeological assemblage, paleobotanical remains and sedimentological documentation have provided multiple sources of information. By combining all of these resources the ambiguity of the reconstruction can be minimized and explicit knowledge of the available resources allows the limits of the model to be evaluated. The main limit within the Sanderson site model has to do with the exact path of the Souris River. It has undoubtedly changed due to its meandering nature and for this reason the modern path of the river has been used. This would not have had a substantial effect on the Sanderson site as its location on a slope at the edge of the floodplain would eliminate the chance of the river ever having directly affected the site.

CHAPTER 3

LATE PREHISTORIC OCCUPATION OF THE REGION

3.1 Introduction

Southern Saskatchewan has a cultural history that goes back to the Clovis culture of 12,000 years ago (Dyck 1983:65). However, the focus of the Rafferty Dam archaeological investigations was the Late Prehistoric Period. A summary of this time period is the only background necessary to provide a knowledge base for dealing with the Sanderson site and all other sites in its locality.

The Late Prehistoric Period is considered to begin about 1750-1250 BP and ends by definition with the coming of the horse about 225 years BP (Vickers and Brink 1986:88) The time period was characterized by the introduction of clay pottery, the bow and arrow and small side-notched projectile points (Dyck 1983:110). The Besant (2000 BP to 1150 BP) and Avonlea (1750 BP to 1150 BP) cultures were the initial cultural complexes in this period and they eventually gave way to the later Side-notched series, the Prairie and Plains Side-notched (1150 BP to 170 BP).

A number of cultural phases have been defined within the Side-notched series, and most of them are classified by ceramics rather than lithics (Figure 3.1). The Sanderson site has generally been agreed to be a Mortlach Phase site (Walde 1994), based on pottery, lithics and other items of material culture. Old Women's Phase and the Cluny complex represent two Plains groups which bordered the Mortlach phase to the west, mainly in the current province of Alberta. To the north and east lay the Selkirk cultures of the boreal forest that are further subdivided into numerous complexes. Finally to the

Figure 3.1. Cultural complexes of the Northern Plains during the later part of the Late Prehistoric (1150 BP to 170 BP).

south lay the plains villagers of North and South Dakota.

The archaeology in the terminal phases of the Late Prehistoric period is unique due to the rich ethnographic evidence from European sources. This has resulted in an overlap in knowledge between scientific archaeological excavations and ethnographic culture histories. Based on this, another time period has been defined within the Late Prehistoric that is based on this European influence on the Northern Plains. The

Protohistoric period begins about 250 years ago and terminates with the coming of the North West Mounted Police in 1874 A.D. (Vickers and Brink 1986:103). Its commencement coincides with the coming of the horse, about 1730-1740 A.D. It is typified by a continual increase in the quantities of European goods, and constitutes the florescence of the Plains Indian culture. The early part of the period from about 1700-1800 is poorly known from historic sources but European observance increases after that period with a flood of scientific and geographical expeditions. The number of discrete ethnic groups that existed at the time is a point of debate due to a limited number of archaeological excavations and contradicting written accounts from the early Europeans.

The discussion of time periods and cultural phases must be done with an awareness that the boundaries are arbitrary. The division between the Late Prehistoric and Protohistoric does not separate the cultural identities that existed in both of them. The Mortlach phase started well before Europeans had even arrived in North America and continued in one guise or another until Europeans were in direct contact with them. It is instead more useful to look at the change within the culture and its activities through time and to consider how the new influences of the Europeans and other native cultures affected them.

3.2 The Mortlach Phase

Initially the Mortlach phase was defined by its pottery alone. This restricted the interpretation and range of variation to one item of material culture. This has been the traditional method of organizing artifacts into culture histories. However the Mortlach Phase could not be defined by a single pottery style. It had a number of different structural designs and exterior decoration including plain, check-stamped, simple-

stamped, cordmarked, fabric impressed, dentate and incised. This is natural when working with such a plastic medium, but it has led to a number of competing approaches in the interpretation of Late Prehistoric ceramics in southern Saskatchewan (Walde 1994:3).

The identifying features of the Mortlach Phase have been defined by Walde (1994). His work represents a synthesis of a number of items of material culture including pottery, ice sliders, and lithics. He sought to find groupings using multiple variables and identifying those that were related by both appearance and function. His clustering helped define the Mortlach phase but also found that there were at least two subphases within this classification. In the north the Lozinsky Sub-Phase seems to have strong interaction with the Selkirk peoples of the boreal forest of central and northern Saskatchewan, while in the south the Lake Midden Sub-Phase seems to show interaction with the Middle Missouri village peoples (Walde 1994:107-108).

Lithics are not the subject of this thesis so only the fact that Mortlach phase sites are associated with Plains side-notched projectile points will be mentioned (Walde et al. 1996:41). Knife River Flint and Fused Shale make up a large number of these points. This distribution of these materials varies between the subphases within the Mortlach phase. Knife River Flint is found frequently and almost exclusively among the Lake Midden sub-phase, indicating an exchange network that was conducted with the Middle Missouri horticulturalists from at least 1500 A.D to the appearance of trade goods in Mortlach Phase assemblages (Wood 1980:100). It seems that this exchange network did not continue up into the parklands to the north, indicating again some kind of difference between the parkland and grassland phases. The bone tool industry of the Mortlach phase

was also well developed. The most studied item are the ice gliders, made of small (15 cm) sections of large mammal rib, likely bison (Walde et al 1996:43).

3.3 Radiocarbon dates for the Mortlach Phase

Absolute dates on Mortlach material are rare. There are a number of calibrated radiocarbon dates available for Saskatchewan and the United States. This would place the Mortlach phase in a time span from about A.D. 1500 to historic times.

Table 3.1. Summary of Radiocarbon dates with calibrations for the Mortlach Phase (Morlan 1993:17-26, Walde et al 1996:44)

Site			14C year BP	Calibrated Age BP				
ID	Site name	Lab No.	Uncalibrated	2s max	1s max	Intercept	1s min	2s min
EcNm-8	Walter Felt	S-280	400 +/- 40	519	508	490	463	320
EfNg-1	Lake Midden	S-2246	380 +/- 100	622	520	476	310	0
FaNp-9	Bill Richards	S-2884	820 +/- 110	950	907	725	670	561
32MN301	Evans	I-7358	395 +/- 80					
	King	Beta 60245	110 +/- 70					

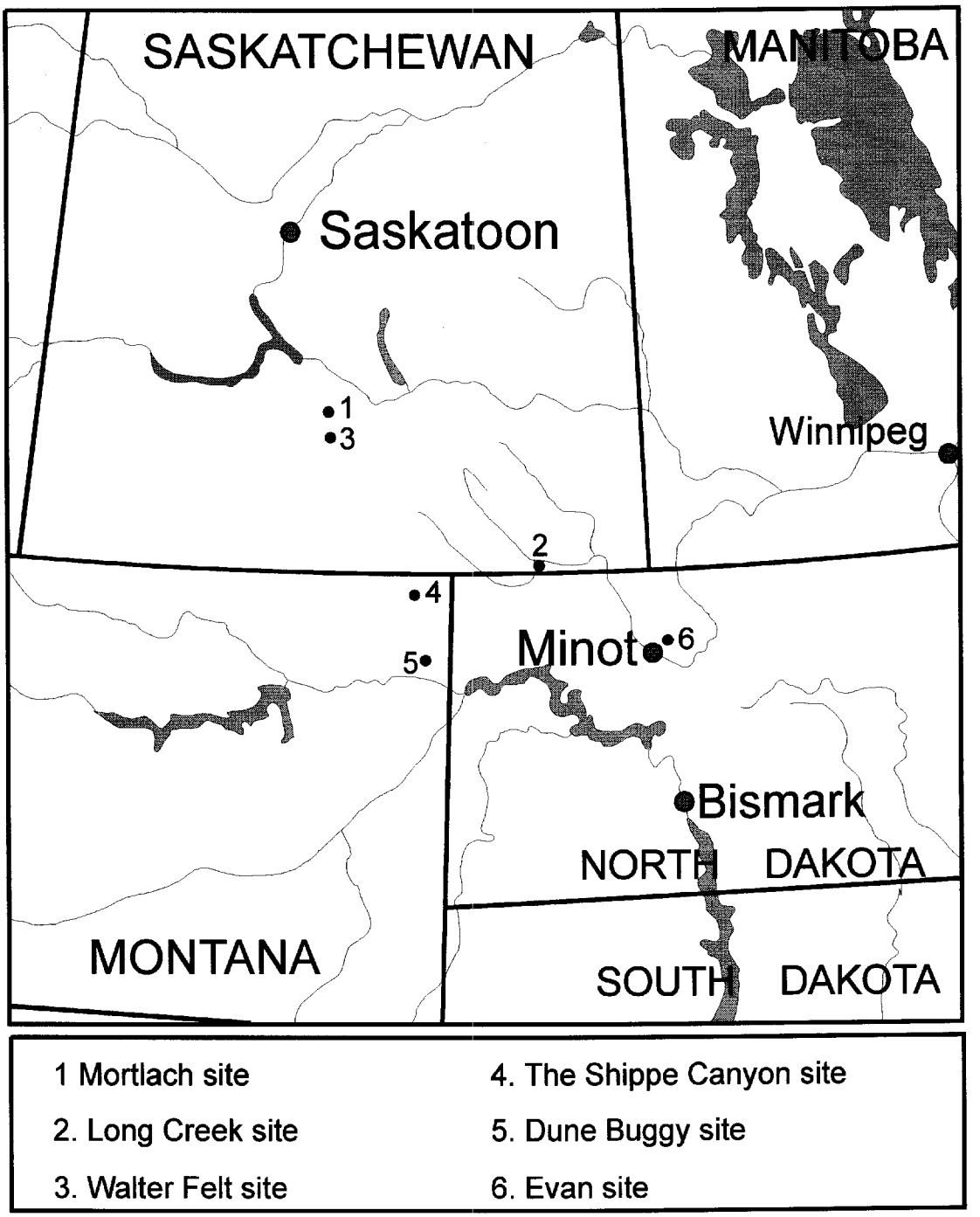
3.4 Mortlach Phase archaeological sites

There are a number of sites associated with the Mortlach Phase in southern Saskatchewan, North Dakota and Montana (Figure 3.2). Although most of the sites were excavated with an emphasis on recovering cultural material some of them provide a comparative sample of faunal material.

3.4.1 Mortlach site (EcNl-1)

The Mortlach site (EcNl-1) was excavated by Wettlaufer in 1954 (Wettlaufer 1955). The site is located six kilometers east of the village of Mortlach in the Besant Valley and was excavated by the Saskatchewan Museum of Natural History. The site was a bison pound with an associated camp area and excavations were carried out in both regions. It was at this site that the Mortlach Phase was initially defined as containing pottery with check-stamped patterns as well as cord roughened and cord wrapped

Figure 3.2. Summary of Mortlach Phase sites on the Northern Plains.



decoration (Wettlaufer 1955:20). Faunal remains were usually not analyzed during this period in archaeology. The only mention of bone with the site is a bone bead found among the assemblage.

3.4.2 Long Creek site

The Long Creek site was excavated by Mayer-Oakes and Wettlaufer in 1957 (Wettlaufer and Mayer-Oakes 1960). The Long Creek site is located in the valley of Long Creek on the south side of the creek, about twelve kilometers south and 1.5 kilometers west of the town of Estevan. It is located on a north-facing slope near a supply of fresh water and sheltered by tree cover. The site was uncovered during construction by the Saskatchewan Power Corporation. The excavation consisted of several ten-foot square excavation blocks that went down through nine cultural layers. Level one was classified as Mortlach Phase based on ceramic similarities between that level and the Mortlach site.

Level one of the Long Creek site is the most detailed faunal analysis from the Mortlach Phase currently in the literature. Level one represents a 20% sample of the bison bone recovered with a 100% recovery of all other faunal material (McCorquodale 1960:87). There is an absence of large mammal species other than bison while the second most common mammal are canids (McCorquodale 1960:88). One common aspect of the bone was its heavily fragmented nature. Carpals and tarsals were often the only bones to survive intact. Even then, the tarsals were often subjected to extreme lateral force in an effort to split them. This lead McCorquodale to conclude that the bones were being heavily utilized for both marrow and grease. The distal end of the limb from the compact bones to the phalanges was then discarded to the canids in the camp. Most of the carpals and tarsals that could be refitted were found close together, indicating to McCorquodale (1960:94) that they had been discarded in articulation and the canids who scavenged them could not separate them. It appeared that most of the bone were

by blows from a heavy and blunt object not disarticulated with a knife. He suggested that the heavy utilization of the bison was likely the result of scarcity of game (McCorquodale 1960:92).

3.4.3 Walter Felt site (EcNm-8) - Upper levels

The Walter Felt (EcNm-8) site is a bison pound site located south of the town of Mortlach, about 16 km southwest of the Mortlach site where Mortlach Check-Stamped was first identified. This site was excavated by Kehoe for the Saskatchewan Museum of Natural History in the summer of 1962 through 1965 (Kehoe 1973:104). The site was multicomponent dating from 450 B.C. to 1550 A.D.. The upper levels were associated with Plains Side-notched projectile points. The faunal remains from the site seems to be concentrated in a mass of bison bone at the site associated with Level 3 (Kehoe 1973:164).

3.4.4 The Shippe Canyon Site(23SH514)

The Shippe Canyon site (23SH514) is a habitation site located south of the town of Plentywood in central Sheridan County, Montana. It is located in a wooded area on the north-facing slope of a coulee. It was excavated in 1968 by Jerde and Joyes although the site was heavily impacted by erosion and pothunters. The site is associated with the Mortlach phase material based on the presence of slotted rib bone handles, bone beads and ceramics (Joyes 1973:55). European trade goods were present in the form of iron scraper blades, a metal projectile point and a gun flint. Late Side-notched and Triangular projectile points were recovered along with a number of other stone tools. There were also bone tools including rib bone knife handles which were slotted for iron blades.

It had been assumed that the site represents a single occupation layer located in the uppermost soil zone. The high density scatter of butchered bone, charcoal, pottery and stone tools define a camp or butchering area located, presumably, near a bison kill site. The faunal material recovered included bison, domestic dogs, coyote, fox, eagle, rabbits, pronghorn antelope and mule deer. Most of the bison bone was fragmented except for bones from the lower extremities many of which were intact. The gully at the bottom of the coulee may have provided a seasonal water supply. Drive lanes have not as yet been found, but the coulee with its steep sides and abundant wood and brush, may have been a highly favourable location for a buffalo pound (Joyes 1973:57).

3.4.5 Dune Buggy site (24RV1)

The Dune Buggy site (24RV1), is located southwest of Froid, Montana. Located along the east bank of Sand Creek, the site is within a copse of trees near a permanent spring. The site was discovered in the 1940s by a River Basin Surveys team as part of the initial mitigation on a dam project. Most of the material collected is from the portion of the site that lies within a cultivated field. Some excavation has been done in addition to the surface collecting. The cultural material ranges back over a 10,000 year period, but there is some evidence of Mortlach culture, mainly based on pottery (Johnson 1977:48)

3.4.6 Evans site(32MN301)

The Evans site (32MN301) was found, near New Town, North Dakota, at the head of a coulee overlooking the Little Knife River. A small excavation was carried out where Schneider and Kenney (1978) placed a 2x2 m excavation unit. There were two components found, the upper one being dated to A.D. 1555+/- 80. Pottery recovered from this level was similar to the Mortlach pottery found at the Shippe Canyon site.

3.5 Conclusions

The Sanderson site seems to fit well into the southern or Lake Midden subphase of the Mortlach phase. This was the Plains-adapted group whose subsistence economy seemed to rely heavily on bison. It also has an abundance of highly comminuted bone that is mentioned at many of the other sites. This is also typical of other groups in this time period who would heavily process bone for the extraction of grease and the manufacture of pemmican. The extreme destruction of most bone has led to a lack of any detailed faunal analysis for most Mortlach sites. This limits the comparative opportunities with the Sanderson site faunal assemblage. Geographically, the Sanderson site is similar in location to many of the other sites. It is on a north-facing slope within a wooded area near a source of fresh water. This is hardly an exclusive site location, however, as many other cultures required sites that were close to fresh water and had abundant firewood resources.

The location of the Sanderson site fits with the settlement pattern seen at other Mortlach sites. The nature and condition of the faunal material are also quite similar although the comparative sample is small. Despite this there is nothing culturally specific about either of these variables as geographic location and processing strategies were mainly dependent on economic and not cultural decisions.

CHAPTER 4

REGIONAL ARCHAEOLOGY

4.1 Site Location

The Sanderson site is located within the Souris River Basin in southeastern Saskatchewan approximately 6 kilometers due south of Hitchcock, Saskatchewan (Figure 4.1,4.2). The location lies along the southern border of Lake McDonald and on the north facing slope of Muirhead's hogback. The site is located beneath a riparian forest canopy, one of the few such vegetation zones in the area. This forest continues down the north facing slope of the hogback for approximately 1.5 kilometers. On the floodplain below the site are extensive marshlands extending for several kilometers in both directions. On the flats above the site are the mixed moist grasslands of the prairies. There are numerous sources of freshwater including many seasonal streams, McDonald Lake and the Souris River.

4.2 Dating

The Sanderson site (DhMs-12) has been dated to a radiocarbon age of 310 ± 75 (SRC #S-2968). The dating was performed on a bone sample taken from level 1. There was no initial adjustment as there has been no proven laboratory systematic offset observed in the Saskatchewan Research Council radiocarbon laboratory. The lab error multiplier (K) was not provided therefore the standard deviation on the radiocarbon age provided by the SRC lab was used to determine the level of error in the radiocarbon date. The date is assumed to have been corrected for isotope fractionation through normalization as this is standard in the reporting procedures of most modern labs. Calculation method A was used within Calib 3.0.3 software. This involves a simple

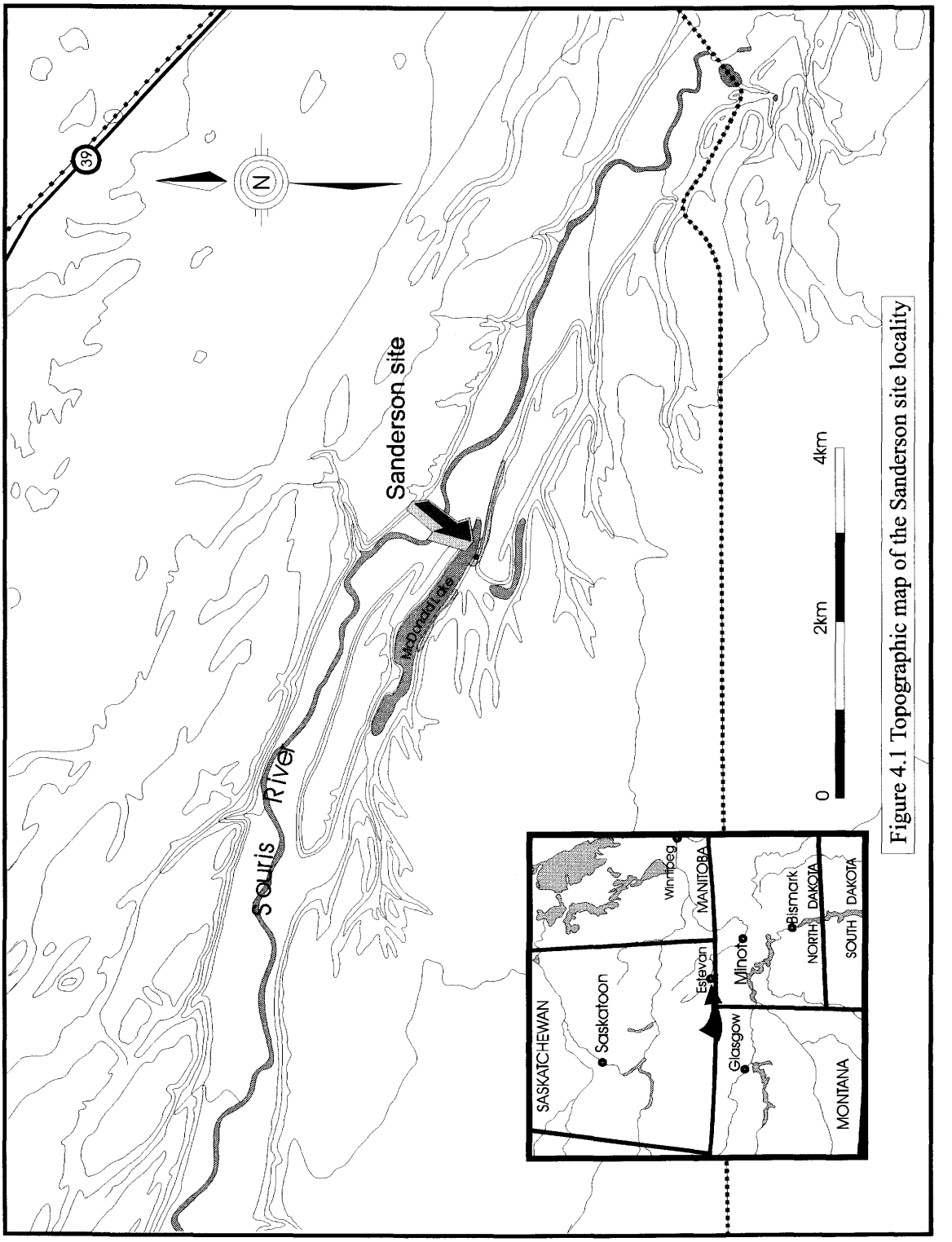


Figure 4.1 Topographic map of the Sanderson site locality

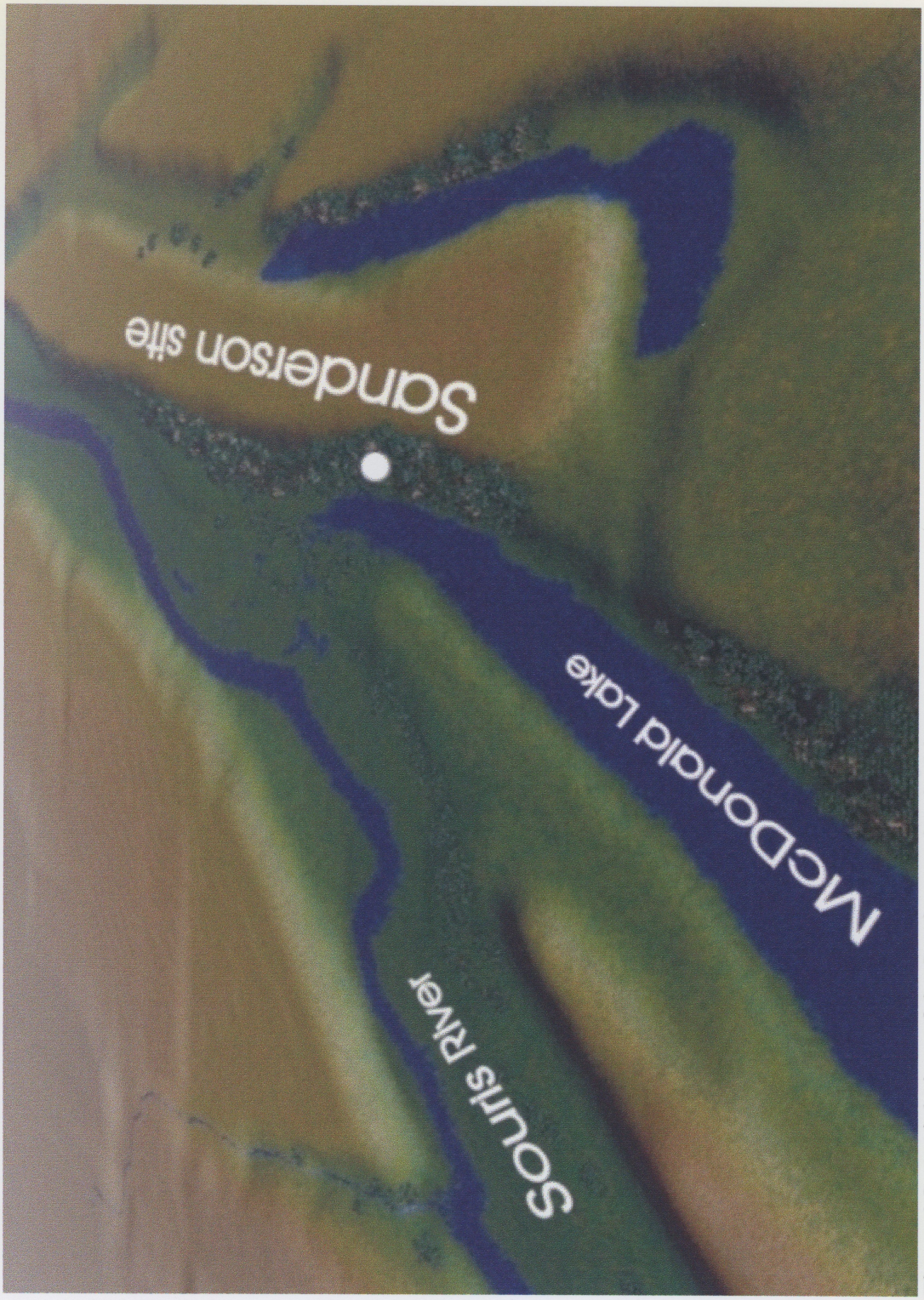


Figure 4.2. Aerial view of the Sanderson site, looking east

intercept with a linear interpolation of the datapoints of the selected calibration dataset. In this case dataset 2 was used which provides a more refined calibration for dates between 0 and 7210 ^{14}C YRBP. This places the calibrated age at three intercepts on the radiocarbon correction curves (Figure 4.3). As Table 4.1 indicates at one sigma

Figure 4.3. Radiocarbon intercepts for the Sanderson site

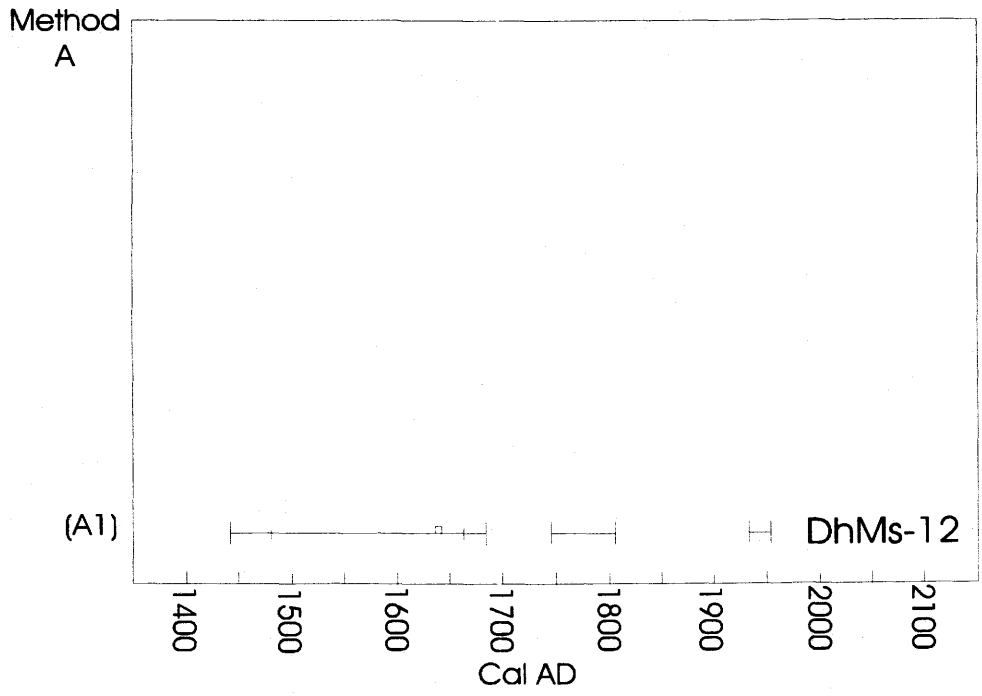


Table 4.1. Radiocarbon data for the Sanderson site based on datasets of Stuiver and Becker (1993:35-65).

%area enclosed	Age ranges: Min (cal age) Max
1δ	cal AD 1486 (1638) 1662 cal BP 464 (312) 288
2δ	cal AD 1438 (1638) 1954 cal BP 512 (312) 0*

* indicates a "negative" age BP

the date at the Sanderson site is 464 to 288 years BP and at two sigma the date is 512 to a negative age in years BP. This would place it far enough back in time that the trade goods

found at site would only represent the very beginnings of European influence on the area. The lower occupation, with its general lack of trade goods would obviously be somewhat older.

4.3 Excavation Techniques

The Sanderson site was excavated in large blocks (figure 4.4). This type of excavation is more suited to the study of spatial distribution and is more efficient when the site deposits have appreciable depth (Finnigan 1989:5). Although the site was not taken deeper than 35 cm, the spatial distribution was invaluable in determining the layout of the site. The basic excavation unit was a 1 x 1 m unit and provenience is controlled to the nearest 50 x 50 cm quad within that unit. Arbitrary levels of 5 cm were used to excavate the site. A 6 mm mesh screened all the excavated earth from the pits. Some of the material was also fine screened through a 2mm mesh is order to recover smaller material. The trenches that were placed through the site were extended down to the edge of the water to see if the site had been covered by recent water levels or if it ended at the modern shoreline.

4.4 Site Stratigraphy

The stratigraphy of the site was recorded from intermittent unit wall profiles done throughout the site. Basically the site is composed of a sod layer to a depth of 2 to 5 cm (figure 4.5), beneath which lies a brown silty loam layer that extends down to at least 35 cm. Splitting this layer at approximately 10 to 15 cm is a layer of sterile gray clay which

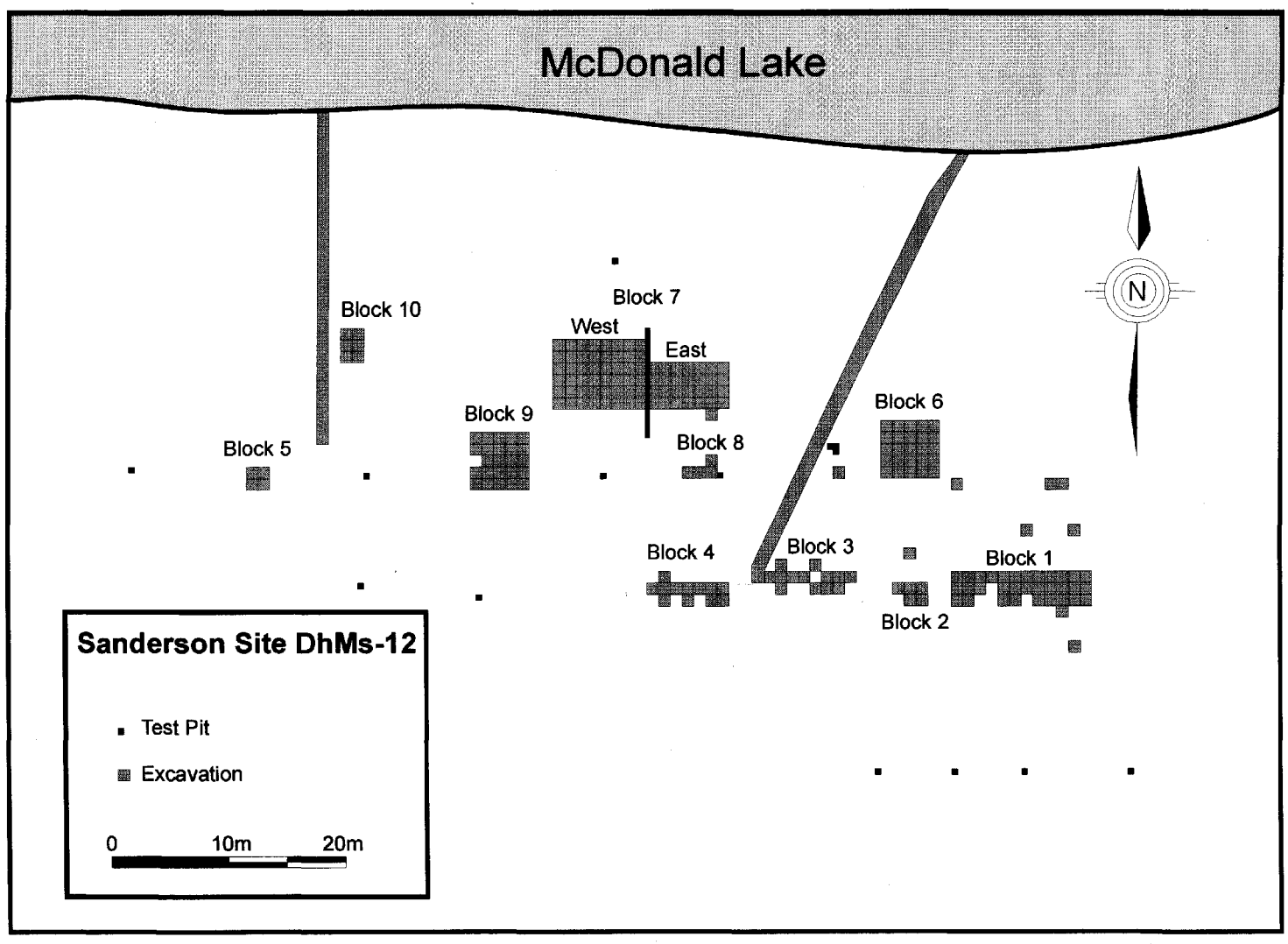
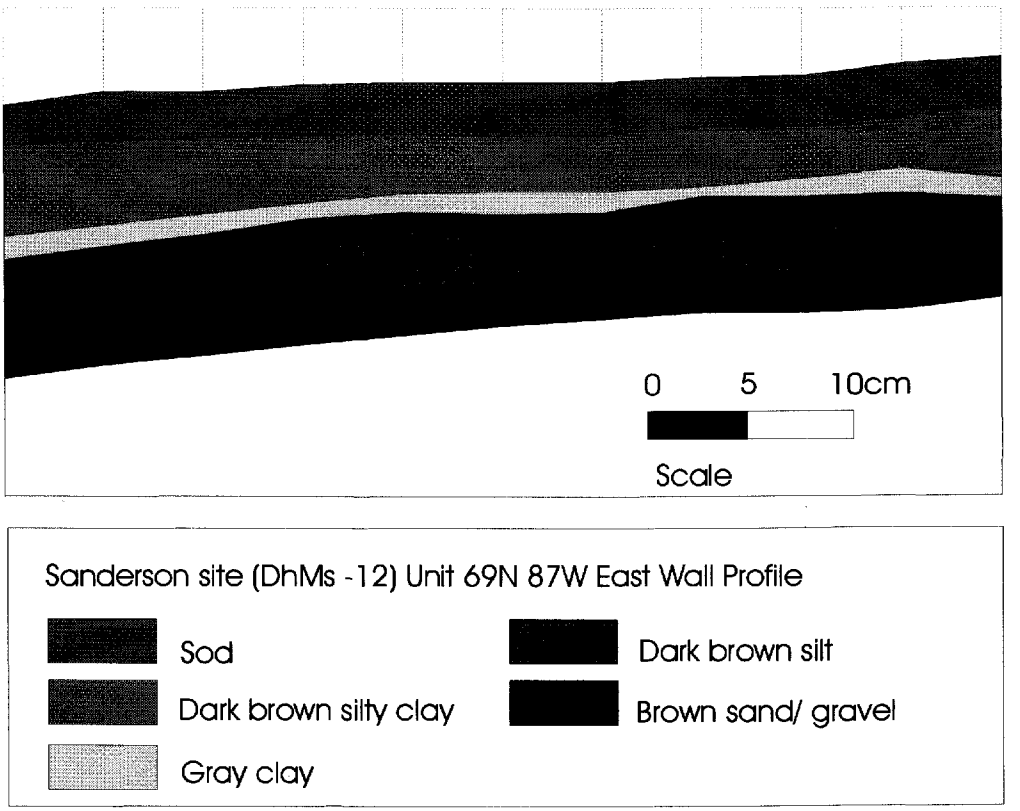


Figure 4.4 Planview of excavation at the Sanderson site

Figure 4.5. Sanderson site soil profile



varies in thickness from 1 to 5 cm.. At the bottom of the site are patches of gravel and brown sand.

4.5 Cultural features and Occupational debris

There are a considerable number of features in block 7 west and block 7 east. Both blocks are included together as some of the features from block 7 west continued on into block 7 east. The numbering of the features is consistent with the level record forms of the initial excavation. Features that were not numbered or identified during this period were given subsequent numbers. The features are separated into occupation level 1 and occupation level 2.

4.5.1 Occupation level 1

There are a number of features, mainly in the form of hearths, located in both the upper and the lower occupations at the site. Figure 4.6 is a summary of all the level one occupation features as well as projectile points found above the sterile gray layer that separated the two occupations.

Feature 19 Occupation 1 Hearth

Feature 19 was a large area of ash located in unit 66N 87W at a depth of five to ten cm. It was surrounded by a large amount of bone and there was a single projectile point associated with it. It did not extend down to level three and seemed to be an ash dump.

Feature 20 Occupation 1 Pit Hearth "Upper Hearth"

Feature 20 was a hearth located mainly in the NE corner of unit 67N 87W although it entered into units 67N 86W, 68N 86W, and 68N 87N. There were at least three projectile points that came out of the hearth ash. The hearth began in occupation one and continued through the clay layer that caps occupation two. The hearth was associated with oxidized earth and was obviously a pit hearth that was dug through the clay layer into the lower occupation. It was likely the source of many of the ash concentrations located in areas around the feature. Figure 4.7 shows a profile of the feature.

Feature 23 Occupation 1 Hearth

Feature 23 was located in 70N 87W, it began at about 13 cm dbs and continued down to 18 cm dbs. The upper portion was made almost completely of ash and the

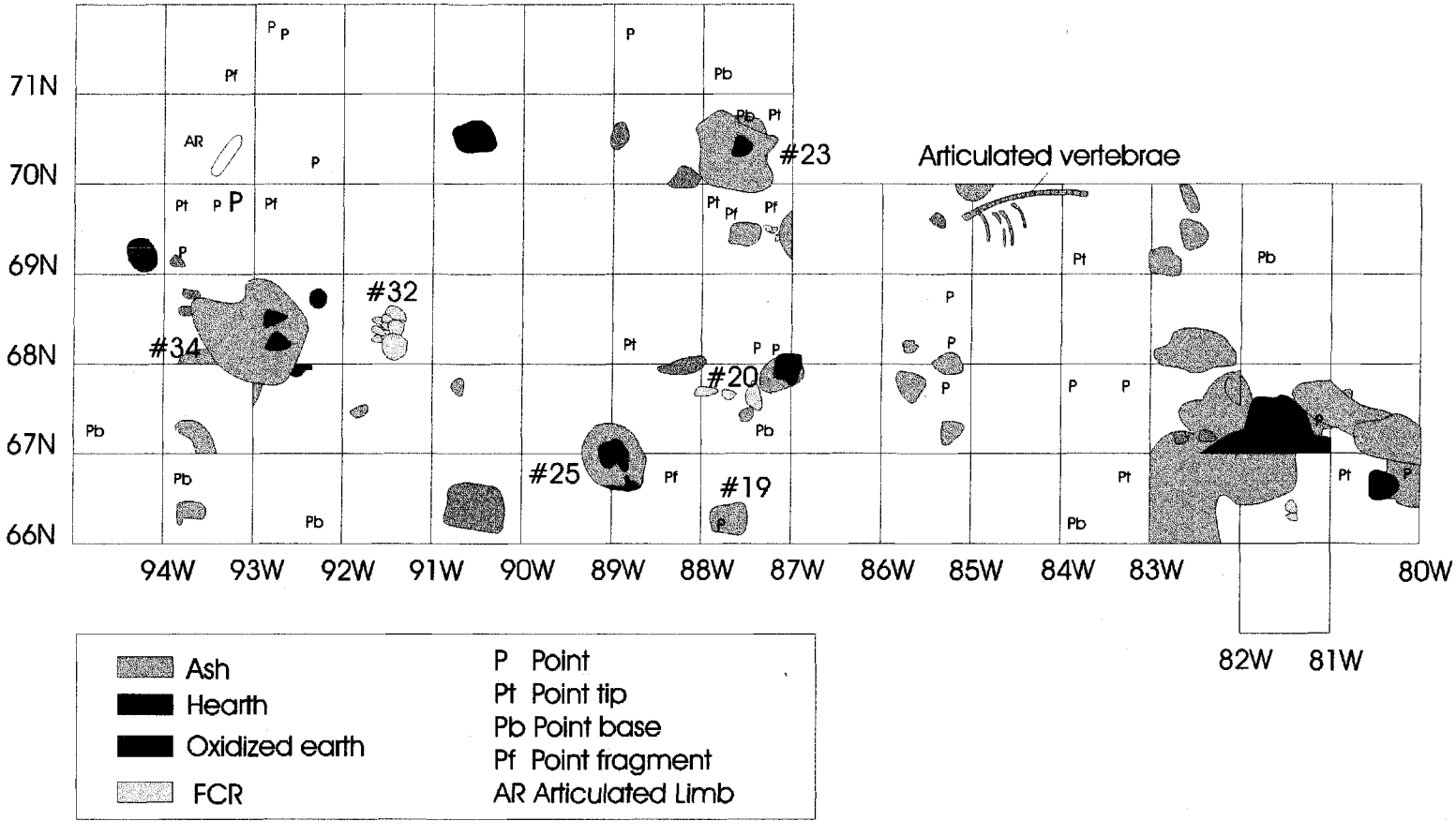
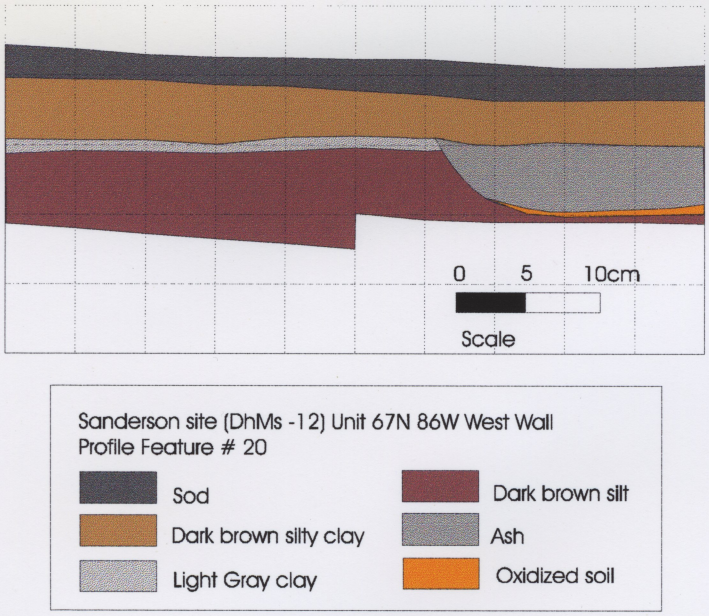


Figure 4.6 Feature summary for occupation 1 of the Sanderson site.

Figure 4.7. Profile of feature # 20, occupation 1.



bottom was composed of orange, oxidized earth. This hearth appeared to start above the clay layer at 15 cm, and extended below the clay layer. It was likely a pit hearth.

Feature 25 Occupation 1 Pit Hearth

Feature 25 began in arbitrary level 2 (5-10 cm dbs) and a small part of it continued down to level 3. There was a small but perceptible basin in the center of the hearth. The hearth was located in the NW corner of unit 68N 88W, the SE corner of unit 67N 88W, the SW corner of 67N 89W and the NE corner of 66N 89W in both the levels. The clay level was not thick at this level but it seemed to appear at the bottom of arbitrary level 2, just below the beginning of this feature.

Feature 32 Occupation 1 FCR pile

Feature 32 began in level two (5-10 cm dbs) and continued down into level three (10-15 cm dbs). It was above the sterile clay layer and there was not enough evidence to determine if it was a boiling pit feature or simply a pile of discarded fire-cracked rock.

Feature 34 Occupation 1 Pit Hearth

Feature 34 was unusual in that it extended down to arbitrary level five (20-25 cm dbs) in unit 68N 92W and 68N 93W. This made it the deepest pit hearth at the site. It appeared to be large depression made up of a collection of ash, rock and oxidized earth. Oxidized earth on level 6 (25-30 cm dbs) indicated that the hearth consisted of a large depression that was lined with a variety of rock.

4.5.2 Occupation level 2

Figure 4.8 is a summary of all the occupation two features as well as projectile points found in the lower occupation, below the sterile clay layer.

Feature 27 Occupation 2 Hearth

Feature 27 began in level four (15-21 dbs) and is mainly in unit 71N 88W. It consisted of an ash lens with an area of burned earth below. There was a projectile point and a point base associated with the ash in the hearth.

Feature 28 Occupation 2 Ash dump

Feature 28 was a thin layer of ash covering the western half of unit 69N 89W, level 3. It is not thicker than 1 cm and had a layer of limestone rock covering it.

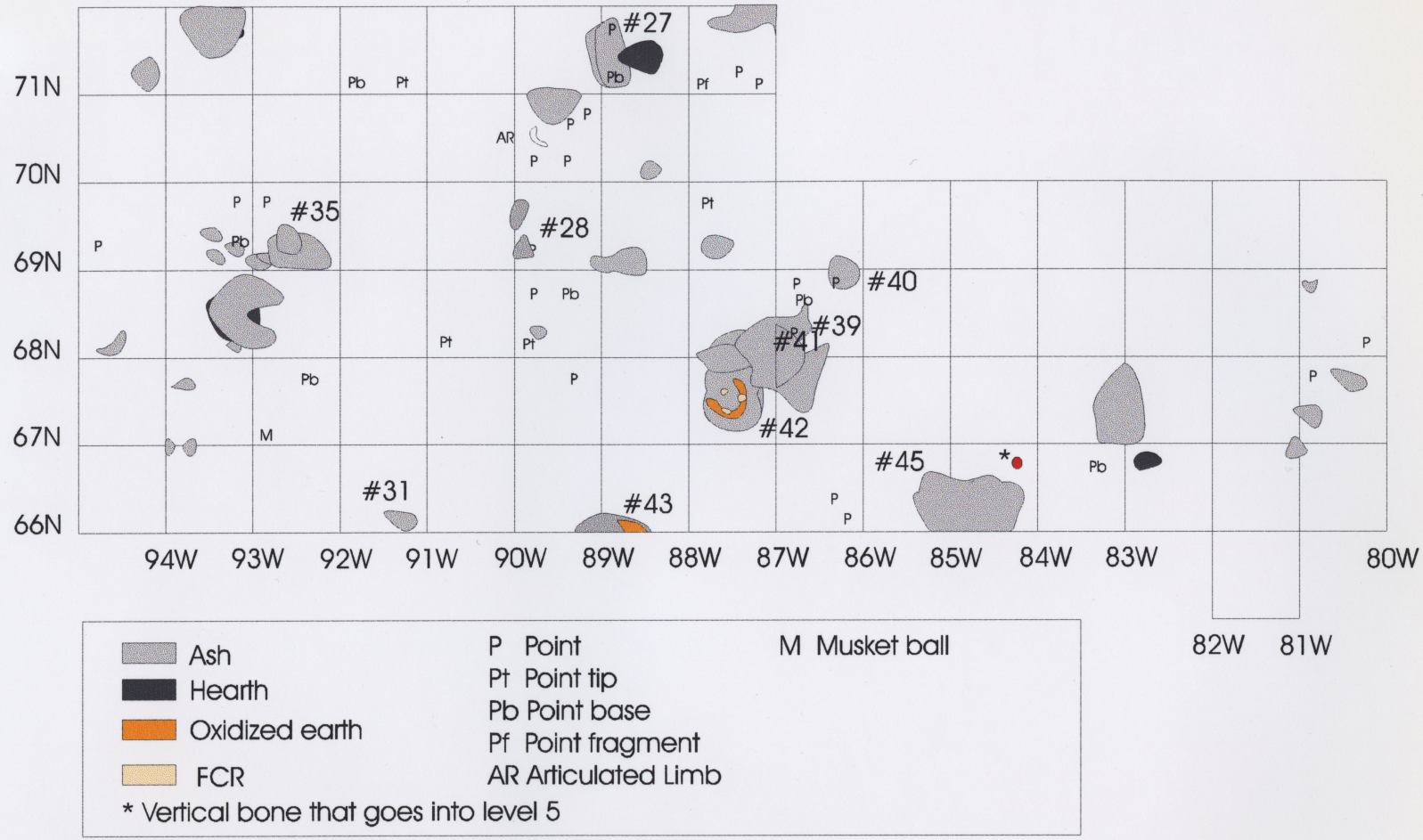


Figure 4.8 Feature summary for occupation 2 of the Sanderson site.

Feature 31 Occupation 2 Hearth

Feature 31 was a small hearth in the SE corner of 66N 91W, level four (15-20cm). It was associated with a projectile point mid-section. It does not appear to penetrate into level five and was likely a small hearth with a limited duration of use.

Feature 35 Occupation 2 Ash dump

Feature 35 was an ash dump that began in the level three (11-16 cm dbs). It extended down to the level six (25-28 cm dbs)

Feature 39 Occupation 2 Pit Hearth "Middle Hearth"

Feature 39 was almost directly underneath feature 20 the "Upper Hearth" from level two. The hearth was bowl shaped and lay in units 67N 86W, 68N 86W, 67N 87W, 68N, 87W. This hearth was directly covered by the sterile clay layer.

Feature 40 Occupation 2 Ash dump

Feature 40 was an ash dump located in unit 68N 86W that began in level four (15-20 cm dbs) and extended down into level five (20-25 cm dbs)

Feature 41 Occupation 2 hearth "Orange Ash Hearth"

Feature 41 was a hearth that lay underneath feature 39. It was primarily located in level five (20-25 cm dps). The center of the hearth extended from 20-27 cm dps.

Feature 42 Occupation level 2 hearth "Gray Ash Hearth"

Feature 42 was south of feature 41 and was located in unit 67N 87W. Although the two hearths looked connected, feature 42 was primarily in level six (25-30 cm dbs) beneath feature 41. The two hearths formed a figure eight of ash on the bottom of the level which supports the idea that they were two discrete hearths.

Feature 43 Occupation 2 hearth

Feature 43 represented a hearth that was coming out of the south wall of unit 66N 88W in level three (10-15 cm dbs). The hearth appeared to be in the second occupation level based on a thin, sparse layer of gray clay at the bottom of level two (5-10 cm dbs).

Feature 45 Occupation 2 hearth

Feature 45 was a shallow hearth that came out of the south wall of unit 66N 84W and 66N 85W. The hearth appeared in level four (15 -20 cm dbs) as an ash concentration and in level five (20-25 cm dbs) as an area of ash concentration and blackened soil.

4.6 Other sites in the area

During the survey and subsequent testing program that was carried out in the area a number of other sites were located in the immediate area around the Sanderson site (figure 4.9). Although all of these sites were noted and recorded, not all of them were tested. The mandate of the SRC only allowed the testing and excavation of sites which were in

jeopardy when the dam construction occurred. Most of the sites are only given a brief summary as their affiliation with the Sanderson site is unknown. Many of them lack diagnostic artifacts but for this same reason they cannot be excluded as having been linked to the Sanderson site.

DgMs-30

This site was made up of five stone circles and was investigated using shovel tests. A low density of cultural material was recovered and suggests that it was a fairly short-term occupation (Finnigan & Klimko 1987:99).

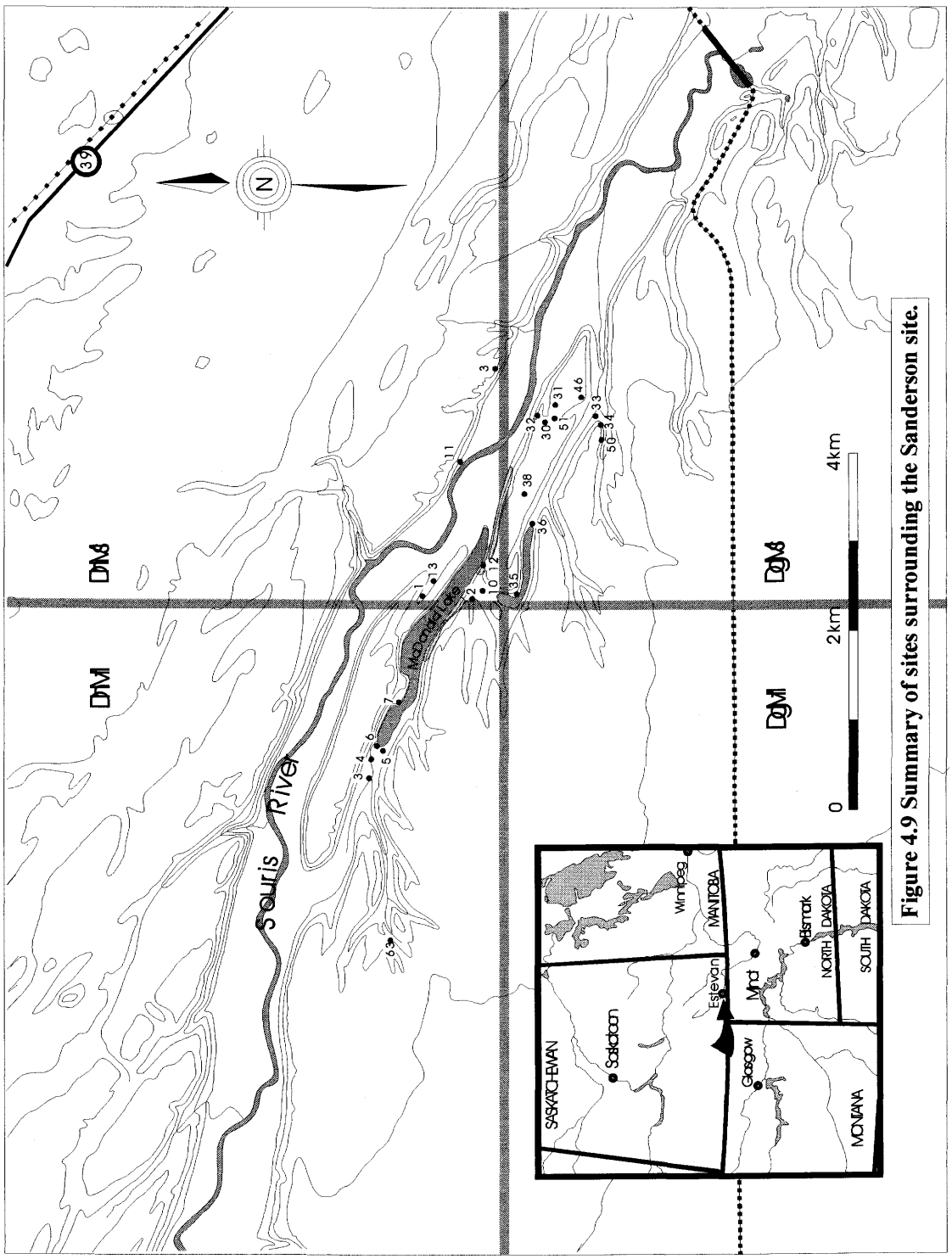


Figure 4.9 Summary of sites surrounding the Sanderson site.

DgMs-32

This site represents another stone circle site but this time with only four stone rings. There was some faunal material but the site consisted of mainly lithic scatter. Indications are that the site was a brief encampment (Finnigan & Klimko 1987:106).

DgMs-33

This site is represented by a single stone ring

DgMs-34

This site was made up of thirteen stone circles but they were not investigated. The patterning of the rings seems to indicate that there was more than one occupation (Finnigan & Klimko 1987:121).

DgMs-35

This site was made up of thirteen stone circles, three cairns and one stone feature. The site is located in a sheltered area near a good water source yet the artifact recovery from the site was poor. The site itself may be related to one or more occupations at the nearby Ratigan site (DhMs-10).

DgMs-36

This site, located on the eastern end of the same body of water as DgMs-35, yielded thirteen stone circles and one cairn. Negligible artifact recovery seems to indicate that the site was one of short occupancy.

DgMs-38

The massive site was made up of 295 stone circles and 41 cairns. No investigations were carried out though because the site was not under threat of inundation.

DgMs-46

This site yielded five stone circles but testing revealed no artifacts at all. Therefore it was likely a small campsite that was occupied for a limited duration.

DgMs-50

Two stone circles were recorded at the site and one had a cairn on its margin. Testing did not recover anything that would have aided the interpretation of this structure's occupation (Finnigan & Klimko 1987:140).

DgMs-51

This was a single stone circle that resulted in a sterile shovel test

DhMs-1

Forty five stone circles and seventeen cairns were recorded at this site. Only eight shovel tests were completed and no diagnostics were recovered from among the cultural material. There was a cairn alignment at the site but its function was unknown. It could possibly have been constructed in historic time when a cart trail was established (Finnigan & Klimko 1987:179) or may be related to the kill site at DhMs-13.

DhMs-2

Located in a slight draw which empties into the coulee containing the Ratigan site this site was made up of three stone circles and two stone features. A large amount of cultural material was recovered from the shovel testing at this site. This included a late

side-notched projectile point and pottery. The site is temporally and spatially related to the larger Ratigan stone circle site (Finnigan & Klimko 1987:145). One interesting aspect of this site is the coulee surrounding it. The topography around the site would not allow it to be visible from the nearby Ratigan site. No data was collected that would indicate whether activity at the site was the same or different from the Ratigan site.

DhMs-3 - Valley Watch site

This site is a fairly large encampment with thirty seven stone rings recorded. It is likely a multicomponent site based on the number of features and the range of depths. Some testing was done, and on that basis the main activity at the site appears to have been lithic reduction (Finnigan & Klimko 1987:118).

DhMs-10 Ratigan site

The Ratigan site was located at the west end of Muirhead's hogback south of McDonald Lake. Ninety four stone circles, twelve cairns and two stone features were recorded. In all 3,414 artifacts were recovered from the test pits, 52.5 % faunal, 32 % lithic, 9.8 % FCR , 5.5 % ceramic sherds and 0.2% items of European manufacture. The site is a multicomponent based on artifact recovery (Finnigan & Klimko 1987:157). It is interesting to note that a prairie side-notched point was found at 18 cm depth while a gun flint was found at 24 cm.

DhMs-11

This site was made up of two stone circles, one cairn and two rock walls. The site yielded lithic debitage, FCR and faunal remains but nothing that would indicate a time period or cultural affiliation. It appears to be a small campsite and from the cultural

material left behind there was a range of activities, including lithic reduction and food preparation which occurred here.

DhMs-13

Based on a small amount of faunal material recovered this site was interpreted as a small kill site (Finnigan & Klimko 1987:189).

DhMt -3

This site was exposed during the construction of a dugout. Testing around the site revealed some pieces of bone and a Besant point. Although the site may have been a small campsite or kill site dating to the Besant phase most of the site was destroyed in the construction of the dugout (Finnigan & Klimko 1987:192).

DhMt-4

This was an isolated stone circle where testing revealed only minor faunal material. The site is likely another encampment used for a brief period by a small group.

DhMt-5

Another isolated stone circle that again only yielded some minor faunal remains. It is again likely that the site was formed by a short occupation by a small group.

DhMt-6

An isolated stone circle that yielded fragmentary faunal remains. It is likely a small group occupied the site for a brief period.

DhMt-7

The site was made up of 14 stone circles and one cairn. The features were separated by low ridges and hills into several groups. Based on the separation of the

features it is likely that more than one occupation is represented by the site (Finnigan & Klimko 1987:192). Testing at the site yielded both faunal material and debitage.

DhMt-63

Three stone circles were recorded at this site. Tests yielded debitage in small amounts making the site likely the result of a brief encampment.

4.7 Summary

The Sanderson site represents a Late Prehistoric occupation which falls well into the Mortlach Phase time frame. A radiocarbon dates on the upper occupation indicates the site is at least 266 years old. The date on the lower occupation would be much older but without radiocarbon dates this can only be a relative observation.

The numerous features in both the upper and lower occupations indicates that there was either one large occupation with multiple hearths or a number of different occupations which have overlapped one another. The best evidence for multiple occupation comes from the lower occupation where three hearths were located almost one atop the other. Although the soil did not present evidence of paleosol formation it is obvious from the deposition between the hearths that they were separated by at least three flooding events.

The Sanderson site is a processing area for faunal material, and the actual affiliation it has to a habitation site is unknown. The largest nearby occupation is the Ratigan site (DhMs-10) and although it is suspected that the two are linked further investigations are necessary (McKeand: personal communication).

CHAPTER 5

THE SANDERSON SITE FAUNAL ASSEMBLAGE

5.1 Introduction

In total 486,914 bone specimens were recovered from the Sanderson site, weighing 422.2 kg (Table 5.1). Block 7 west was comprised of 173,097 bone specimens with a weight of 134.1 kg. Nearly 95% of the total assemblage represented unidentifiable

Table 5.1 The Sanderson site faunal assemblage weight and specimen totals

Block No.	Id. Faunal No.	Unburned	% unburned	Id Faunal weight (g)	Total Fauna No.	% Ident.
Block 1	7091	6331	89.3	42830	74840	10.46
Block 2	245	216	88.2	2561	3928	6.65
Block 3	715	626	87.6	6494	7816	10.06
Block 4	210	203	96.6	1855	3363	6.66
Block 5	35	32	91.4	457	688	5.30
Block 6	4334	3727	86.0	34168	72090	6.39
Bk 7east	3239	2137	66.0	28690	87757	3.83
Bk 7west	6434	3504	54.5	57480	173097	3.86
Block 8	235	213	90.6	1915	3047	8.35
Block 9	2074	1396	67.3	13958	49001	4.41
Block 10	208	53	25.5	2044	11287	1.87
Site	24820	18438	74.3	192454	486914	5.37

Block No.	Unid. Faunal No.	Unburned	% unburned	Unid. Faunal weight (g)	Total Fauna No.	%Unident.
Block 1	67749	52498	77.5	40158	74840	90.52
Block 2	3683	3376	91.7	1807	3928	93.76
Block 3	7101	5933	83.6	3740	7816	90.85
Block 4	3153	2859	90.7	2185	3363	93.75
Block 5	653	588	90.0	503	688	94.91
Block 6	67756	49654	73.3	27771	72090	93.98
Bk 7east	84518	51266	60.7	42187	87757	96.30
Bk 7west	166663	87057	52.2	76615	173097	96.28
Block 8	2812	2275	80.9	2354	3047	92.28
Block 9	46927	26839	57.3	26784	49001	95.76
Block 10	11079	3548	32.0	5630	11287	98.15
Site	462094	285893	61.9	229740	486914	94.90

bone specimens while 96.3 % of the Block 7 west specimens were unidentifiabl. Bone specimens are defined as archaeologically discrete elements that were recovered from the site and can be identified as bone whether fragmented or whole. Identifiable bone specimens are those bone specimens which have enough defining characteristics to allow identification to taxon. Before it is possible to identify the bone specimen to taxon it is necessary to identify the skeletal element. This is a broader use of the term "specimen" as defined by Lyman (1994:39) but it is necessary as there was no terminology defined for dealing with the unidentifiable portions of a faunal assemblage. The unidentifiable bone specimens of Block 7 west made up 57.1% of the total weight of the faunal material from the block.

Most of the faunal assemblage at the Sanderson site was composed of bison bone. Although bison dominates the assemblage it is not the only species found at the site. There are also a substantial number of canid remains, both wild and domestic, and a wide variety of local mammal, avian and piscine remains recovered from the site.

In total 19 taxa (Table 5.2) recovered from both occupations at the Sanderson site. This included six avian, 15 mammalian, and one piscine. Most of the taxa recovered from the site still exist in the area today. The exceptions are the bison, swift fox, wolf and elk which have been driven from their ranges by European and agricultural activity.

Table 5.2 Summary of the Sanderson site faunal material from Block 7 west.

Species		Occ 1		Occ 2	
Common Name	Scientific Name	NISP	MNI	NISP	MNI
Avian					
Canada goose	*Branta canadensis*	12	1	1	1
Mallard duck	*Anas platyrhynchos*	3	1	5	1
Blue-winged teal	*Anas discors*	6	1	-	-
Indeterminate raptor	Accipitrid sp.	1	1	-	-
Indeterminate swan	*Cygnus sp.*	9	1	-	-
	Phasianid sp.	2	1	-	-
Mammalian					
White-tailed Jackrabbit	*Lepus townsendii*	4	1	-	-
Beaver	*Castor canadensis*	5	1	-	-
Richardson' s Ground squirrel	*Spermophilus richardsonii*	12	1	4	1
	Spermophilus sp.	2	1	-	-
Meadow vole	*Microtus pennsylvanicus*	1	1	1	1
Muskrat	*Ondatra zibethicus*	1	1	-	-
Mink	*Mustela vison*	2	1	-	-
Skunk	*Mephitis mephitis*	2	1	-	-
Badger	*Taxidea taxus*	2	1	-	-
Pronghorn	*Antilocapra americana*	3	1	1	1
Elk	*Cervus elaphus*	-	-	3	1
Swift fox	*Vulpes velox*	10	3	15	2
	Small *Canis sp.*	12	1	15	1
	Medium *Canis sp.*	9	2	18	2
	Large *Canis sp.*	85	2	65	1
Wolf	*Canis lupus*	2	1	-	-
Domestic dog	*Canis familiaris*	2	1	2	1
Bison	*Bison bison*	2014	12	1278	10
	Piscine	23	-	9	-

All of the mammalian distribution maps in the faunal remains description section were created in the Faunmap online GIS database created by the Illinois State Museum (Appendix V). The time period represented by the distributions is Post-Contact, only the past 500 years up until historic times. The locations marked on the map correspond to

archaeological excavations where the same fauna was found for the Post-Contact time period. The gray areas represent the distribution of the species during modern times but before the large extinctions began to occur on the Northern Plains.

5.2 Mammalian Faunal Remains

Class Mammalia, Order Artiodactyla, Family Bovidae

Bison bison

Table 5.3 presents the *Bison bison* element counts

Discussion: A total of 173,097 bone specimens weighing 134.1 kg was recovered from Block 7 west of the Sanderson site. Only 6434 of these specimens were identifiable and 95% of these identifiable elements represent large ungulates. Occupation one yielded 3869 large ungulate bone specimens and occupation two yielded 2191 bone specimens. Unfortunately 44.3 % of the occupation one and 39.1 % of the occupation two total was comprised of indeterminate ungulate dental enamel. Two factors, the occurrence of elk (*Cervus elaphus*), and pronghorn (*Antilocapra americana*) at the site, and the small size of much of the dental enamel fragments, means that this category cannot be automatically assigned to *Bison bison*. In total 45 % of the bison assemblage exhibited burning.

The fact that only 3.8 % of the sample was identifiable attests to the high level of fragmentation of the bone assemblage at the site. There were also high NISP counts despite average MNI counts in the cranial, mandibular and rib elements, also indicating a high level of fragmentation in these fragile elements.

Table 5.3 Bison element counts from occupation one and two of the Sanderson site

	Occ 1				Occ 2			
	NISP	Total MNE	Total MAU	MNI (side)	NISP	Total MNE	Total MAU	MNI (side)
Axial Elements								
Cranium	241.0	15.0	7.5	11.0	195.0	11.0	5.5	6.0
Mandible	225.0	14.0	7.0	9.0	128.0	6.0	3.0	5.0
Hyoid	3.0	2.0	1.0	1.0	4.0	3.0	1.5	2.0
Sternum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rib head	43.0	43.0	1.6	2.0	3.0	3.0	0.2	1.0
Atlas	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Axis	7.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0
Cervical	31.0	6.0	0.9	1.0	37.0	8.0	1.1	1.0
Thoracic	86.0	10.0	0.8	1.0	35.0	5.0	0.4	1.0
Lumbar	49.0	17.0	2.8	3.0	31.0	6.0	1.0	1.0
Sacral	6.0	6.0	6.0	6.0	4.0	4.0	4.0	4.0
Caudal	3.0	3.0	0.2	1.0	4.0	4.0	0.2	1.0
Appendicular Elements								
Forelimb								
Scapula	20.0	3.0	1.5	2.0	20.0	2.0	1.0	2.0
Humerus	45.0	8.0	4.0	6.0	50.0	10.0	5.0	7.0
Radius	52.0	13.0	6.5	7.0	49.0	6.0	3.0	6.0
Ulna	30.0	6.0	3.0	4.0	24.0	6.0	3.0	4.0
Radial carpal	11.0	10.0	5.0	6.0	8.0	7.0	3.5	5.0
Internal carpal	14.0	11.0	5.5	7.0	10.0	9.0	4.5	5.0
Ulnar carpal	11.0	10.0	5.0	5.0	11.0	8.0	4.0	4.0
Accessory carpal	4.0	4.0	2.0	3.0	4.0	4.0	2.0	3.0
Carpal 2+3	12.0	9.0	4.5	6.0	12.0	9.0	4.5	6.0
Unciform	7.0	7.0	3.5	5.0	7.0	7.0	3.5	5.0
Metacarpal	18.0	6.0	3.0	3.0	23.0	5.0	2.5	3.0
Hindlimb								
Innominate	23.0	6.0	3.0	5.0	24.0	5.0	2.5	3.0
Femur	29.0	11.0	5.5	6.0	17.0	9.0	4.5	5.0
Patella	3.0	3.0	1.5	2.0	6.0	6.0	3.0	5.0
Tibia	136.0	15.0	7.5	11.0	61.0	15.0	7.5	10.0
Calcaneous	15.0	5.0	2.5	4.0	17.0	10.0	5.0	8.0
Astragalus	12.0	6.0	3.0	3.0	23.0	14.0	7.0	7.0
Tarsal C+4	21.0	15.0	7.5	12.0	8.0	5.0	2.5	4.0
Tarsal 2+3	13.0	13.0	6.5	10.0	11.0	11.0	5.5	8.0
Tarsal 1	2.0	2.0	1.0	1.0	1.0	1.0	0.5	1.0
Lateral malleolus	11.0	11.0	5.5	6.0	16.0	16.0	8.0	8.0
2nd metatarsal	3.0	3.0	1.5	1.0	5.0	5.0	2.5	3.0
Metatarsal	19.0	4.0	2.0	3.0	19.0	9.0	4.5	7.0

Table 5.3 continued

	Occ 1 NISP	Occ 1 Total MNE	Occ 1 Total MAU	Occ 1 MNI (side)	Occ 2 NISP	Occ 2 Total MNE	Occ 2 Total MAU	Occ 2 MNI (side)
Other Appendicular								
1st phalanx	33.0	21.0	2.6	3.0	32.0	21.0	2.6	3.0
2nd phalanx	52.0	35.0	4.3	5.0	59.0	38.0	4.8	5.0
3rd phalanx	16.0	9.0	1.1	2.0	17.0	14.0	1.8	2.0
Sesamoids								
Superior-lateral	26.0	26.0	3.3	4.0	27.0	27.0	3.4	4.0
Superior-medial	24.0	24.0	3.0	3.0	29.0	19.0	3.6	4.0
Inferior	12.0	12.0	1.5		17.0	17.0	2.1	3.0
Other axial								
Vertebra indet.	48.0	-	-	-	7.0	-	-	-
Rib shaft	128.0	-	-	-	38.0	-	-	-
Indet long bone	445.0	-	-	-	167.0	-	-	-
Other appendicular								
Metapodial	24.0	-	-	-	15.0	-	-	-
Totals	2014.0				1278.0			
Indeterminate ungulate								
Dental enamel	1713.0				857.0			
Totals	3727.0				2135.0			

Class Mammalia, Order Artiodactyla, Family Antilocapridae

Antilocapra americana

Occupation 1

Antilocapra americana (Pronghorn) NISP = 3: lumbar vertebrae (DhMs-12: 52010), upper right P2 (69196), left lower P2 (73993).

Occupation 2

Antilocapra americana (Pronghorn) NISP = 1: fused second and third tarsal (52831).

Discussion: The only pronghorn bones to exhibit burning are those of occupation 2. None of the bones has any indication of cutmarks or carnivore chewing.

They usually inhabit the plains, steppes, deserts and foothills. They tend to disperse into male and female herds over the summer but come together during the winter as they migrate into the more protected valley and coulees (Banfield 1977:402).

Class Mammalia, Order Artiodactyla, Family Cervidae

Cervus elaphus

Occupation 1

None

Occupation 2

Cervus elaphus (Elk) NISP=2: tibia shaft (66112), left distal humerus (65387), right distal humerus (56006)

Discussion: *Cervus elaphus* remains are only found in the lower occupation. The left distal humerus exhibited cutmarks and was large enough to fall into the range exhibited by female bison. It was differentiated from bison using the methods of Brown and Gustafson (1989:62).

Class Mammalia, Order Lagomorpha, Family Leporidae

Lepus townsendii

Occupation 1

Lepus townsendii (White-tailed jackrabbit) NISP = 4: central tarsal bone (DhMs-12: 53258), 2 right distal humerii (69533, 67714), right proximal tibia (69532).

Medium-sized Leporid (Snowshoe-Hare sized) NISP = 2: immature cervical vertebra (51979), unfused proximal radius (56377).

Occupation 2

Medium-sized Leporid (Jackrabbit-sized) NISP = 1: right radius shaft (DhMs-12: 52829)

Discussion: Most of the leporid skeletal material could be identified down to species although some of it was too fragmented and ambiguous. The number of different species of rabbit and hare inhabiting the region year round made it impossible to assign this ambiguous material to any one species. Most of the bone appears to be contemporaneous with the occupation levels. Some of the elements in level one do not have the same level of weathering as other bones in the level and are likely intrusive. There was no evidence of burning or cutmarks on any of the bones. The White-tailed Jack Rabbit lives year round on the prairie, mainly in thickets and grasslands but they will occasionally penetrate forests in search of shelter from harsh weather.

Class Mammalia, Order Rodentia, Family Castoridae

Castor canadensis

Occupation 1

Castor canadensis (Beaver) NISP = 5 : unfused lumbar vertebra (DhMs-12: 57638), rib shaft fragment (49144), right humerus, proximal epiphysis unfused (66025), right femur, epiphyseal ends unfused (71083), right femur, greater trochanter epiphysis (71068).

Occupation 2

None

Discussion: The unfused nature of the material likely represents of a single immature individual. There was no evidence of burning or cutmarks on any of the bones.

Class Mammalia, Order Rodentia, Family Sciuridae

Spermophilus sp.

Occupation 1

Spermophilus sp. NISP = 1: immature thoracic vertebra (DhM2-12: 65408), thoracic vertebra (48683), lumbar vertebra (73560), cervical vertebra (73603), unfused sacrum (73547), left proximal femur (73535), right proximal femur (73538), right distal femoral epiphysis (73602), left acetabulum (73568), right innominate (73549), left tibia (73980), right scapula (74005), right immature femur (57334).

Occupation 2

Spermophilus sp. NISP = 2 lumbar vertebrae (DhMs-12: 49091,56609), right distal humerus (56885).None

Spermophilus richardsonii

Occupation 1

Spermophilus richardsonii (Richardson's Ground Squirrel) NISP = 12: (left mandible with I_1, P_1(DhMs-12: 73601).

Occupation 2

Spermophilus richardsonii (Richardson's Ground Squirrel) NISP = 4: right mandible with I_1, P_1 (DhMs-12: 52790).

Discussion: The numerous elements of *Spermophilus richardsonii* may be intrusive but more likely they are the result of cultural activity as there are several burned elements. These include some distal limb elements and the incisors in both of the jaws. This, and a similar level of staining with other bones in that level, places the material in the same time period as the hearths in the first and second occupation. Most of the material from level one was clustered in one unit and was likely from a single immature individual. None of the material exhibited digestive corrosion or tooth marks but root etching may have obscured this evidence. *Spermophilus richardsonii* prefers rolling hills of gravely or sandy soils in which to burrow. It is quick to move into cultivated fields and avoids wetlands. These animals hibernate in the winter and reach full size by the end of September (Banfield 1977:115).

Class Mammalia, Order Rodentia, Family Cricetidae

Microtus pennsylvanicus

Occupation 1

Microtus pennsylvanicus (meadow vole) NISP = 1: right mandible with M_1 (DhMs-12: 65098)

Cricetid indeterminate NISP = 1: right mandible with I1 (67412).

Occupation 2

Microtus pennsylvanicus (meadow vole) NISP = 1: lower left M_1 (51351)

Cricetid indeterminate NISP = 1: right mandible (55337)

Discussion: All four of these mandibles are sufficiently weathered to be associated with the site. Only two of the mandibles had intact molars, allowing species identification. All of the elements exhibited burning although there was no other sign of cultural modification.

Microtus pennsylvanicus does not hibernate but lives in colonies during the winter, and disperses in the summer, staying active year-round. It survives on a herbivorous diet of fresh greens in the summer and stored caches during the winter. It prefers wet meadows where there is a protective carpet of grasses (Banfield 1977:210). The cover at the site and the nearby marsh meadows would have provided ideal habitat for this vole species. These animals were of minor economic importance in prehistoric times as their winter caches were gathered for foodstuffs (Banfield 1977:211).

Class Mammalia, Order Rodentia, Family Muridae

Ondatra zibethicus

Occupation 1

Ondatra zibethicus (Muskrat) NISP = 1: left proximal humerus (DhMs-12: 48521).

Occupation 2

None

Discussion: The excellent condition of the bone and lack of staining would seem to indicate that the specimen is recent. There was no evidence of burning, cutmarks or carnivore chewing. Muskrats would be likely inhabitants of the area due to the local lake and embankments for burrow construction.

Class Mammalia, Order Carnivora, Family Mustelidae

Mustela vison

Occupation 1

Mustela vison (American Mink) NISP = 2: atlas (DhMs-12: 53152), left proximal radius (58732).

Occupation 2

None

Discussion: The materials exhibit root etching and weathering indicating that neither specimen are recent. Neither bone exhibited evidence of butchering or burning.

Minks usually inhabit burrows along river banks or in the roots of trees. They are active hunters year-round and their prey includes fish, small mammals and birds. They occur throughout southern Saskatchewan

Mephitis mephitis

Occupation 1

Mephitis mephitis (Striped skunk) NISP = 2: left mandible, M_1 (DhMs-12: 49637).

Occupation 2

None.

Discussion: These materials exhibit root etching and weathering indicating that neither of the specimens are recently intrusive. There is no evidence of butchering or burning.

Skunks usually hibernate through the winter from early December to late March. Their diet is omnivorous, and they have few natural enemies other than the Great Horned Owl. They usually inhabit forests and river valleys, preferring the cover vegetation. They have been reported to be good to eat and were consumed by natives in the past (Banfield 1977:340).

Taxidea taxus

Occupation 1

Taxidea taxus (Badger) NISP = 2: Mandible, left C_1, P_{1-4}, M_1; right C_1, P_{2-4}, M_1 (DhMs-12: 54993), proximal phalanx (55073).

Occupation 2

None

Discussion: These materials exhibit root etching and weathering indicating that none of the specimens is recently intrusive. Badgers do tend to hibernate in the winter from November to April. Their habitat is usually the open prairie where they hunt fossorial animals as well as other small mammals (Banfield 1977:335). They have no natural enemies and are considered extremely formidable. It is unlikely that the remains were deposited through carnivore activity.

Class Mammalia

Occupation 1

Medium-sized mammal (rabbit-sized) NISP = 18: 2 long bone shafts (DhMs-12: 52352, 52371), rib shaft fragment (52358, 55153, 55193, 55074), mandibular ramus (56379),

femoral head (55127), distal femoral epiphysis (53914), tibial shaft (55063), vertebral arch fragment (49711).

Occupation 2

Medium-sized mammal (rabbit-sized) NISP = 3: long bone fragment (51108), mandiblular ramus (51531), vertebral arch fragment (51161).

Discussion: The number of species of medium sized mammals at the site means that species identification of small fragmented remains that are lacking any diagnostic landmarks is essentially impossible.

Class Mammalia, Order Carnivora, Family Canidae

Introduction

The canid remains at the Sanderson site were extensive and although fragmented many exhibited an excellent state of preservation. Considering the sample size and the importance of canids the subsistence and economy of Late Prehistoric cultures the canids will be subjected to a more intense analysis than most of the other mammalian remains. Speciation of the material was difficult due to its fragmentary nature. This was compounded by the existence of large domestic dogs used for the purposes of pack animals, small domestic dogs used as pets and food sources and wolf/dog hybrids. It means that there is likely an overlap in the size of *Canis lupus*, *Canis latrans* and *Canis familiaris*. There is no reliable method of discriminating fragmentary post-cranial remains of canids so there is no potential for differentiating this material. Any elements which could not be differentiated to species on craniometric or dental measurements were

classified as *Canis sp.*. This would have required a large clumping of the canid material so in order to separate out this large group all material that fell into a similar size range to *Canis latrans* was placed in small *Canis sp.* Undifferentiated canid material that fell into the size range of *Canis lupus* was placed in a large *Canis sp.* and all other specimens which fell between these two sizes were categorized as medium *Canis sp.*

Vulpes velox

Table 5.4 presents the *Vulpes velox* element counts

Discussion: The swift fox was once found over much of southern Saskatchewan but is now extinct in the area. It forms burrows in an open area of the plains, often with no shade (Banfield 1977:302). Remains from both upper and lower occupations are dominated by cranial and forelimb elements. There was no evidence of cutmarks, carnivore chewing or digestive corrosion in the swift fox material. There is evidence of burning on 27 % of the occupation 1 and 30 % of the occupation 2 swift fox material respectively. The summary of analysis in Table 5.4 indicates that there was at least two individuals in the lower occupation and at least three individuals in the upper occupation.

Table 5.4 The NISP, MNE, MAU and MNI of the Swift fox (*Vulpes velox*) by element and occupation level.

	Occupation 1				Occupation 2			
Vulpes velox **element counts**	Total NISP	Total MNE	Total MAU	MNI (side)	Total NISP	Total MNE	Total MAU	MNI (side)
Group								
Element								
Axial Elements								
Cranium	0.0	0.0	0.0	0.0	5.0	2.0	0.5	1.0
Mandible	2.0	2.0	2.0	2.0	6.0	2.0	1.0	2.0
Vertebrae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.4 con't								
Forelimb								
Scapula	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Humerus	5.0	3.0	1.5	3.0	3.0	3.0	1.5	2.0
Radius	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulna	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carpals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metacarpals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hindlimb								
Innominate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Femur	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Patella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tibia	0.0	0.0	0.0	0.0	1.0	1.0	0.5	1.0
Tarsals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metatarsals	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Other appendicular								
Phalanges	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	10.0				15.0			

Small *Canis sp.* (coyote-sized)

Table 5.5 presents the small *Canis sp.* element counts.

Discussion: The small *Canis sp.* elements are almost exclusively restricted to cranial elements and distal appendicular elements. In total, 42 % of the occupation one material and 15 % of the occupation two elements exhibited evidence of burning. There was no evidence of cutmarks or digestive corrosion in the small *Canis sp* material. The summary of table 5.5 indicates that there was at least one individual in occupation one and one individual in occupation two.

Table 5.5. The NISP, MNE, MAU and MNI of the small *Canis sp.* by element and occupation level

Small *Canis sp.* element counts	Occupation 1 Total NISP	Total MNE	Total MAU	MNI (side)	Occupation 2 Total NISP	Total MNE	Total MAU	MNI (side)
Group								
Element								
Axial Elements								
Cranium	6.0	1.0	1.0	1.0	3.0	1.0	0.5	1.0
Mandible	1.0	1.0	0.5	1.0	3.0	2.0	1.0	1.0
Atlas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Axis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cervical	1.0	1.0	0.1	1.0	0.0	0.0	0.0	0.0
Thoracic	0.0	0.0	0.0	0.0	1.0	1.0	0.1	1.0
Lumbar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sacral	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Caudal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hyoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sternum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forelimb								
Scapula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Humerus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Radius	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Radial carpal	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Other carpals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Second metacarpal	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Other metacarpals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hindlimb								
Innominate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Femur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tibia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Calcaneous	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Other tarsals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metatarsals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other appendicular								
First phalanx	2.0	2.0	0.3	1.0	2.0	1.0	0.1	1.0
Second phalanx	0.0	0.0	0.0	1.0	5.0	3.0	0.4	1.0
Third phalanx	1.0	1.0	0.1	1.0	1.0	1.0	0.1	1.0
Totals	15.0				15.0			

Medium *Canis sp.*

Table 5.6 presents the medium C*anis sp.* element counts

Discussion: This category includes canids in size between size small *Canis sp.* (coyote-sized) and Large *Canis sp.* (wolf-sized). The pattern of skeletal frequencies is consistent with those of small *Canis sp.*, mainly cranial and distal appendicular elements being left at the site. The number of burned element total 17 % in occupation 1 and 30 % in occupation 2. Only one instance of cutmarks could be found on a rib fragment from the second occupation. Analysis indicates that there were at least two individuals in the upper occupation and one individual in the lower occupation.

Table 5.6 The NISP, MNE, MAU and MNI of medium-sized canids by element and occupation level

	Occupation 1				Occupation 2			
Medium Canis sp.. element counts	Total NISP	Total MNE	Total MAU	MNI (side)	Total NISP	Total MNE	Total MAU	MNI (side)
Group Element								
Axial Elements								
Cranium	0.0	0.0	0.0	0.0	1.0	1.0	0.5	1.0
Mandible	5.0	2.0	1.0	2.0	8.0	2.0	1.0	2.0
Atlas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Axis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cervical	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thoracic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lumbar	0.0	0.0	0.0	0.0	4.0	1.0	0.1	1.0
Sacral	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caudal	1.0	1.0	0.1	1.0	0.0	0.0	0.0	0.0
Hyoid	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sternum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rib	4.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
Forelimb								
Scapula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Humerus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Radius	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ulna	0.0	0.0	0.0	0.0	1.0	1.0	0.5	1.0
Carpals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metacarpals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.6 con't Hindlimb								
Innominate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Femur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tibia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tarsals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Second metatarsal	0.0	0.0	0.0	0.0	1.0	1.0	0.5	1.0
Other metatarsals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other appendicular								
First phalanx	0.0	0.0	0.0	0.0	1.0	1.0	0.1	1.0
Second phalanx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Third phalanx	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indt. metapodial	0.0	0.0	0.0	0.0	2.0	1.0	0.1	1.0
Totals	10.0				18.0			

Large *Canis sp.*(wolf-sized)

Table 5.7 presents the large *canis sp.* element counts

In terms of body part representation the large *Canis sp.* remains represent the most numerous canid remains at the site. Only 6 % of the occupation one remains were burned while 19 % of the occupation two remains exhibited charring. Less than 1 % of the occupation one remains exhibited carnivore chewing while there was no evidence at all in occupation two. Arthritic lipping occurred in 27 % of the vertebral and rib tubercle elements in occupation one. This may be an indication that one individual of extreme age was part of the assemblage. If this individual represents a complete carcass at the site it would account for most of the post- cranial remains found in occupation one. In total, there were at least two individuals in occupation one and three individual in occupation two. There is a fairly even occurrence of axial and appendicular elements based on the MAU and MNI of the canids in occupation one.

Table 5.7 The NISP, MNE, MAU and MNI of large *Canis sp.* by element and occupation level.

Large *Canis sp.* element counts	Occupation 1 Total NISP	Total MNE	Total MAU	MNI (side)	Occupation 2 Total NISP	Total MNE	Total MAU	MNI (side)
Group								
Element								
Axial Elements								
Cranium	5.0	1.0	1.0	1.0	6.0	2.0	1.0	1.0
Mandible	0.0	0.0	0.0	0.0	4.0	1.0	1.0	1.0
Atlas	3.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0
Axis	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cervical	1.0	1.0	1.0	1.0	3.0	1.0	1.0	1.0
Thoracic	7.0	5.0	0.7	1.0	2.0	2.0	1.0	1.0
Lumbar	5.0	4.0	0.6	1.0	2.0	1.0	1.0	1.0
Sacral	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
Caudal	6.0	6.0	0.3	1.0	5.0	1.0	0.1	1.0
Hyoid	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Sternum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ribs	4.0	1.0	0.0	1.0	2.0	1.0	0.0	1.0
Forelimb								
Scapula	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Humerus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Radius	4.0	2.0	1.0	2.0	0.0	0.0	0.0	0.0
Ulna	0.0	0.0	0.0	0.0	3.0	2.0	1.0	1.0
Radial carpal	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0
Ulnar carpal	2.0	2.0	1.0	1.0	1.0	1.0	0.5	1.0
First carpal	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Fourth carpal	0.0	0.0	0.0	0.0	1.0	1.0	0.5	1.0
Other carpals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
First metacarpal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Second metacarpal	1.0	1.0	0.5	1.0	2.0	2.0	1.0	1.0
Third metacarpal	2.0	2.0	1.0	1.0	2.0	2.0	1.0	1.0
Fourth metacarpal	2.0	2.0	1.0	2.0	2.0	2.0	1.0	1.0
Fifth metacarpal	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0
Hindlimb								
Innominate	2.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0
Femur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Patella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tibia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
First tarsal	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Third tarsal	1.0	1.0	0.5	1.0	1.0	1.0	0.5	1.0
Fourth tarsal	1.0	1.0	0.5	1.0	1.0	1.0	0.5	0.0
Central tarsal	0.0	0.0	0.0	0.0	1.0	1.0	0.5	1.0
Other tarsals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Second metatarsal	0.0	0.0	0.0	0.0	1.0	1.0	0.5	1.0
Third metatarsal	1.0	1.0	0.5	1.0	2.0	2.0	1.0	1.0
Fourth metatarsal	1.0	1.0	0.5	1.0	0.0	0.0	0.0	0.0
Other metatarsals	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 5.7 continued **Large *Canis sp.* element counts**	Occ 1 Total NISP	Total MNE	Total MAU	MNI (side)	Occ 2 Total NISP	Total MNE	Total MAU	MNI (side)
Group								
Element								
Other appendicular								
First phalanx	2.0	2.0	1.0	1.0	4.0	4.0	0.3	1.0
Second phalanx	2.0	2.0	1.0	1.0	3.0	3.0	0.2	1.0
Third phalanx	0.0	0.0	0.0	0.0	1.0	1.0	0.1	1.0
Indt. metapodial	4.0	4.0	0.5	1.0	5.0	5.0	0.3	1.0
Sesamoid	3.0	3.0	0.2	1.0	0.0	0.0	0.0	0.0
Indt. long bone	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	85.0				65.0			

Canis lupus

Table 5.8 presents the *Canis lupus* element counts.

Discussion: Wolves do not exhibit any habitat preference and are found from the arctic to the open plains (Banfield 1977:292). The subspecies affiliation is likely *Canis lupus nubilis*, or the prairie wolf, which became extinct in southern Saskatchewan with the extermination of its main food source, the bison.

Table 5.8 The NISP, MNE, MAU and MNI of large *Canis lupus* by element and occupation level.

***Canis lupus* element counts**	Occupation 1 Total NISP	Total MNE	Total MAU	MNI (side)	Occupation 2 Total NISP	Total MNE	Total MAU	MNI (side)
Group								
Element								
Axial Elements								
Mandible	15.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Totals	15.0				0.0			

Species identification was based on a number of craniometric and dental measurements detailed in the following chapter. Although it is likely that some of the

remains that are classified as large *Canis* sp. are wolves it is impossible to separate them from any large domestic dogs in the same assemblage.

Canis familiaris

Table 5.9 presents the *Canis familiaris* element counts.

Discussion: *Canis familiaris* represents domestic species of dogs. The are likely associated with the human activity at the site. Species identification was based on a number of craniometric and dental measurements detailed in the following chapter.

Table 5.9 The NISP, MNE, MAU and MNI of large *Canis familiaris* by element and occupation level.

	Occupation 1				Occupation 2			
Canis familiaris	Total	Total	Total	MNI	Total	Total	Total	MNI
element counts	NISP	MNE	MAU	(side)	NISP	MNE	MAU	(side)
Group								
Element								
Axial Elements								
Cranium	21.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
Mandible	4.0	1.0	1.0	1.0	7.0	1.0	1.0	1.0
Totals	26.0				7.0			

5.3 Avian Faunal Remains

Class Aves, Order Anseriformes, Family Anatidae

Occupation 1

Cygnus sp.(Indeterminate Swan). NISP = 9: right distal humerus (DhMs-12:69739, 69748), right proximal humerus (69724), left proximal coracoid (70031), rib head and tubercle (70118, 69687), synsacrum (69692,69704), right proximal carpometacarpus (67416).

Occupation 2

None

Discussion: These nine fragments likely represent one individual due to their proximity. Only 50 % of the bones exhibited any evidence of burning. There was no evidence of cutmarks or carnivore modification of any of the bones.

Class Aves, Order Anseriformes, Family Anatidae, Tribe Anserini

Occupation 1

Branta canadensis (Canada Goose) NISP = 12: left proximal scapula (Dhms-12:70032, 69722), right scapula (69740), left carpometacarpus (69721), right cuneiform (69725), sternum (69726), manubrium (69738), right coracoid (69988).

Occupation 2

Branta canadensis (Canada Goose) NISP = 1: left second phalanx (58731).

Discussion: Due to their proximity the fragments from occupation one are likely from the same individual. Cutmarks occur on the cranial portion of the sternum fragment and burning appears on the coracoid fragment from occupation one. The occupation two element is heavily weathered, possibly a combination of root erosion and digestive corrosion. The Canada goose breeds over much of Canada and winters in the extreme south of Canada, including southern Saskatchewan., and down into the southern United States (Godfrey 1986:80).

Class Aves, Order Anseriformes, Family Anatidae, Tribe Anatini

Occupation 1

Anas platyrhynchos (Mallard) NISP = 3: right coracoid (DhMs-12:52670), cervical vertebrae (69116), proximal humerus (53041).

Occupation 2

Anas platyrhynchos (Mallard) NISP = 5: right scapula (65482), right coracoid (65524), right humerus shaft (65483), distal right coracoid (65481), proximal right coracoid (65525).

Discussion: The remains from occupation two show very little weathering while occupation one material shows some root erosion. The occupation two bones likely represent the right wing element from a single bird in view of the proximity of the elements. There was no evidence of burning or cutmarks on any of the bones. The mallard duck ranges throughout Canada and can be found breeding in southern Saskatchewan in the spring and living in the area throughout the summer and fall but rarely winters in the Estevan area (Godfrey 1986:86).

Class Aves, Order Anseriformes, Family Anatidae, Tribe Anatini

Occupation 1

Anas discors (Blue-winged Teal) NISP = 6: left distal femur (DhMs-12:52027), left distal humerus(52646), left tibiotarsus shaft (49082), left proximal carpometacarpus (52009), right humerus (66940), right coracoid (66936).

Occupation 2

None.

Discussion: The left wing elements of occupation one are close enough together that they probably represent an articulated unit that was slightly scattered. The single hindlimb was also from the left side. The right wing elements were also found close enough together that they likely represent a discarded limb or feather fan. There was no evidence of burning or cutmarks on any of the bones. The Blue-winged Teal breeds in southern Canada but winters in the southern United States (Godfrey 1986:88).

Class Aves, Order Anseriformes, Family Anatidae

Occupation 1

Medium Anatid (duck-sized) NISP = 8: sternum (56268), left proximal ulna (66111), left proximal ulna (68800), right proximal ulna (65890), left distal tibiotarsus (67377), 2 cervical vertebrae (57759,68794), axis vertebra(68904).

Occupation 2

Medium Anatid (duck-sized) NISP = 3: Ulna shaft (65978), distal tibiotarsus (66027), proximal radius (57879).

Discussion: Although these bones match the size and morphology of the other medium sized anatid species they are lacking any diagnostic features to allow species identification. Some of the bones exhibit evidence of burning while others appear to have suffered digestive corrosion.

Class Aves, Order Falconiformes, Family Accipitridae

Occupation 1

Medium-sized Accipitrid (NISP = 1: third phalanx (72819)

Occupation 2

none

Discussion: The existence of trees at the site would have made an excellent nesting and hunting area for raptors. There are abundant avian and rodent resources in the local marsh areas. The single element is likely at the site because of hillwash or natural deposition. It shows no evidence of having been culturally modified.

Class Aves, Order Galliformes, Family Phasianidae

Occupation 1

Medium Phasianid NISP = 2: right distal femur, unfused (72747), right proximal femur, unfused (72763).

Occupation 2

None.

Discussion: There was no evidence of burning or cutmarks on any of the bones. There are numerous phasianids that inhabit the area including the Greater Prairie-Chicken (*Tympanuchus cupido*) and the Sharp-tailed Grouse (*Tympanuchus phasianellus*) (Godfrey 1986:162).

Class Aves

Occupation 1

Aves indeterminate (medium sized) NISP = 6: vertebra (68825), 3 long bone shafts (52678, 48662,69689), scapula fragment (65145), distal tibiotarsus fragment (50128).

Occupation 2

Aves indeterminate (medium-sized) NISP = 1: long bone shaft (53499).

5.4 Past environment

One of the purposes of including distribution maps of all the species is to illustrate that all the animal species found at the Sanderson site were within their predicted ranges. The distributions of animals is often determined by the environment in which they thrive. Many of the animals such as the wolf and coyote are extremely adaptable and are found in a wide range of environments. It is the animals which have a more specific niche which are more useful in forming a picture of the site during its formation. Micromammals present one of the best opportunities to reconstruct a local environments as they are usually only located within a certain ecotone.

Environmental variations in the Late Prehistoric on the Northern Plains were not extreme. These would likely not have affected the site any more than modern day seasonal fluctuations. The biggest environmental change has been the introduction of agriculture and irrigation in the surrounding area. In the immediate area a dam was built less than 150 meters from the site. This activity in the area could easily have affected the modern appearance of the site. McDonald Lake, the riparian tree canopy and the nearby

marshes were all used in the landscape reconstruction of the site. In order to use the reconstruction it is necessary to establish that these resources existed at the time of site formation as they served to attract faunal resources and ancient people to the area.

McDonald Lake is a major draw to wild fowl during the spring and fall migrations. Its still water and year-round existence make it preferable to the flowing water of the nearby Souris River. It also would have been a major food source during the migration periods. The presence of migratory waterfowl in both occupation levels at the Sanderson site indicates that the lake has at least existed during the spring and fall migration is not merely a creation of the more modern dam project. It is still likely that the lake would have disappeared during seasonal droughts.

The beaver and muskrat at the site also support the long term existence of the lake. Both of these rodents prefer still water with stable banks for burrowing and creating dens. The Souris river alone would not have provided this type of environment as its annual flooding and meandering nature would have been destructive to the rodent burrows.

Micromammals are another useful tool in reconstructing past environments. They tend to prefer either wet or dry conditions and are usually found consistently in one or the other. The existence of meadow vole in the site seems to indicate that the rich, wet meadows that were found on the flood plains below the site had been there for the last few hundred years.

Other species such as skunk are not as specific but it prefers forested areas and some type of cover. Their preference for this type of cover indicates that the forest surrounding the site running along the hogback were likely a good refuge for wildlife for the past several hundred years.

Some animals such as the pronghorn and the badger are more adapted to the open prairie than to a moist, forested environment. The mix of all these animals would seem inconsistent were it not for the unique environment of the riverine canopy forest. This ecozone allows a rich, moist forested environment only a few hundred meters from the open prairie grasslands at the top of the valley edge. The existence of dry environment and wet environment mammals in the same faunal assemblage is likely the result of human transport from the nearby ecotone or an overlap in foraging ranges for these animals.

5.5 Distribution of Faunal Remains

The distribution of faunal remains was carefully split among all the different species and elements to determine if any patterns appeared at the site (Table 5.10). Only identified elements were used to determine patterns as the unidentified elements would have quickly dominated the maps, obscuring any concentrations of known elements. Considering the large number of different species of animal found at the site, all of the distribution maps were compiled in Appendix II in order to shorten this section of the thesis.

Table 5.10 Summary of faunal concentrations with related features

Occupation 1	
Feature #19 (Hearth)	*Bison bison* forelimb elements *Bison bison* hindlimb elements
Feature # 20 (Pit Hearth "Upper Hearth")	*Vulpes velox* *Bison bison* cranial elements *Bison bison* vertebral elements *Bison bison* forelimb elements *Bison bison* hindlimb elements
Feature # 23 (Hearth)	*Vulpes velox* *Bison bison* vertebral elements *Bison bison* hindlimb elements
Feature # 25 (Pit Hearth)	*Vulpes velox* *Bison bison* cranial elements *Bison bison* vertebral elements *Bison bison* forelimb elements
Feature #32 (FCR concentration)	*Bison bison* vertebral elements *Bison bison* forelimb elements *Bison bison* hindlimb elements
Feature #34 (Pit Hearth)	Anatids *Canis lupus* *Vulpes velox* *Bison bison* vertebral elements *Bison bison* forelimb elements *Bison bison* hindlimb elements
Anatid hearth (70N 90W)	Anatids
Rodent hearth (69N 94W)	Rodents

Table 5.10 con't **Occupation 2**	
#27 (Hearth)	*Bison bison* hindlimb elements *Bison bison* forelimb elements
#28 (Ash Dump)	*Bison bison* cranial elements *Bison bison* vertebral elements
#31 (Hearth)	Indet. Canid *Canis latrans* *Canis lupus* *Bison bison* forelimb elements *Bison bison* hindlimb elements
#35 (Ash Dump)	Anatids *Canis latrans*
#42 (Hearth "Gray Ash Hearth")	Rodents *Bison bison* vertebral elements *Bison bison* forelimb elements *Bison bison* hindlimb elements
#43 (Hearth)	*Canis lupus* *Bison bison* vertebral elements *Bison bison* forelimb elements *Bison bison* hindlimb elements

5.5.1 Bison elements

Immature elements

The counts for immature elements include both fetal and immature elements under one year of age based on the size of the bone element. The NISP included all identified elements other than dental enamel. Occupation one has one large concentration

of immature elements centered around 67N 94W (Figure 1, Appendix II). This corresponds with feature # 34, a large hearth to the east of the concentration. The concentration continues northward along the hearth until it runs out.

Occupation two has a few areas of low concentration, although none of them are very large (Figure 2, Appendix I). The concentration at 68N 94W is likely contamination from occupation one as the hearth feature #34 was a large pit hearth and the depression may have carried some of the elements into the lower occupation level. The other concentrations are related to hearth feature #31 and hearth feature #42.

Mature elements

The individual portions of the bison were grouped into cranial, vertebral, forelimb and hindlimb elements as well as phalanges and sesamoids. This was done in order to determine if the elements were spatially grouped within the site (Table 5.11). The different portions of the bison had varying amounts of utility, therefore, it is important to see if they are treated differently in their placement.

Table 5.11 Definitions of categories used in bison element distribution maps

Cranial elements	All cranial elements except teeth
Vertebral elements	Cervical, Thoracic, Lumbar, Sacral, and Caudal vertebrae
Forelimb elements	Scapula, Humerus, Radius, Ulna, Carpals, and Metacarpal
Hindlimb elements	Femur, Tibia, Tarsals, and Metatarsals
Phalanges	All phalanges from fore and hindlimb
Sesamoids	All sesamoids from fore and hindlimb

Cranial elements

The cranial elements of the bison are difficult to evaluate due to the fragile nature of the skull. It becomes highly fragmented leading to a high NISP count so that concentrations within the site are related to the fragility of the element as well as the frequency of that element. With this in mind, occupation one has one large concentration at 68N 88W which corresponds with feature #20 (Figure 3, Appendix II). There is one other concentration at 66N 89W which corresponds with feature #25 but the other, smaller concentrations do not seem to have any association with recognized features.

Occupation two has only one large concentration which corresponds with hearth feature # 28 (Figure 4, Appendix II). There is one other concentration at 70N 87W but there is no feature in the surrounding area. The head of the bison provided food from the tongue, nose and brains. Despite this it does not appear that this part of the bison was being processed near the hearth activity areas.

Vertebral elements

The vertebral elements were also clustered throughout both of the occupations. In occupation one there were a number of clusters including one at 68N 93W which corresponds to the hearth feature #34 (Figure 5, Appendix II). Another cluster at 68N 91W is located within feature #32, a concentration of fire-cracked rock and likely a boiling pit feature. There is an extremely heavy concentration at 66N 89W which is beside feature # 25. This area also corresponds to a concentration in occupation two and the hearth feature #43. This overlap of concentration may be due to the location of the

two hearths within a meter of one another or it may be the result of mixture of the two occupation levels. A similar situation occurs at 67N 87W where there is a concentration in both the upper and lower level at the same locations. Both concentrations are beside hearth feature # 20 in level one and hearth feature # 42 in occupation two. This may again be due to mixture of materials from the two levels or simply the existence of two hearths located almost one below the other. There is also a concentration of vertebral elements that runs between hearth feature #20 and hearth feature #23, forming a continuous concentration between the two features. There are two more small concentrations in the northwest part of the block that do not correspond to any other features. They are located within the area of projectile point concentration and may represent a disposal area for processed faunal material.

Other than the previously mentioned concentrations in occupation two there are a few small concentrations. The one centered around 70N 91W is likely associated with hearth feature #35 (Figure 6, Appendix II).

Forelimb elements

There are a number of concentrations of forelimb elements within the first occupation (Figure 7, Appendix II). The cluster at 68N 93W corresponds to the large hearth feature #34 while the cluster to the east of the hearth at 68N 91W corresponds to the FCR concentration feature #32. The cluster protruding from out of the wall of the block at 66N 92W does not correspond to any recognized feature but it may be related to an undiscovered feature south of the excavated block. The cluster at 67N 90W is next to

hearth feature #25 although its orientation to the northeast of the feature also puts it within a meter of the FCR concentration feature #32. The clusters at 67N 88W and 69N 88W are more problematic as they correspond with concentrations from occupation two and may represent contamination or the existence of multiple hearths stacked on top of one another in this very small area. These clusters correspond with hearth features #19 and #20 in the upper occupation. There is again a large generalized clustering of elements in the northeast portion of the quad that does not correspond to any feature at the site.

Occupation two has a number of concentrations although not all of them seem connected to any features (Figure 8, Appendix II). The concentration at 71N 94W may be related to hearth feature #35 although it is over a meter away from the feature. It may also represent a disposal pit that is intrusive from level one and corresponds with the diffuse concentrations of the northwest corner of occupation one. The break in element concentration at 68N 93W is likely the result of the pit hearth #34 from occupation one which would have been dug through the lower levels, removing the material from occupation two. The concentration at 66N 94W has no known feature associated with it. Its location in the south wall of the block may indicate that any features associated with the cluster remain unexcavated. Hearth feature #31 is associated with the cluster at 66N 91W. The close proximity of the hearth to the southern wall of the excavation demonstrates how features just beyond the area of excavation can be responsible for concentrations of materials within the excavation. The concentration at 68N 90W has no

associated feature in occupation two. There is also no feature above it in occupation one that could account for its placement. Feature #28 is about a meter to the north of the cluster and there is a concentration of materials which seems to define the outline of the hearth up to the concentration at 71N 90W. This area also corresponds to a projectile point concentration around hearth #28 and an articulated limb. The area may have been a disposal point for processed faunal material. There is one other concentration at 71N 88W which is related to hearth feature #27. One of the largest clusters at the site is at 67N 88W which is next to hearth feature #42. The edges of the concentration define feature #42, #41 and #39 all of which occur within a meter of one another.

Hindlimb elements

There are a few areas of hindlimb element concentration in occupation one that overlap areas of forelimb concentration in the same level (Figure 9, Appendix II). These include the areas of 68N 93W and 68N 91W as well as the general concentration in the northwest corner of the block. The area of 68N 93W is related to the hearth feature #34 while the area of 68N 91W falls next to the FCR feature #32. It makes sense that both hindlimb and forelimb elements were being processed for food at feature #34 and then grease at feature #32. There are a number of concentrations along the south wall at 90W, 91W, and 94W that do not seem to be related to any features. Like the forelimb concentrations along the wall, they may be related to features that were unexcavated to the south of the block. There is another concentration at 67N 87W which is between feature #19 and Feature #20 with a large generalized concentration around the

surrounding area. As there are three hearths located within two meters of one another this concentration is likely related to them all. A small concentration is found at 70N 88W and is likely associated with hearth feature #23.

The occupation two hindlimbs also have a number of areas of concentration that correspond with the forelimbs in the same occupation (Figure 10, Appendix II). The areas of 68N 90W, 66N 91W, 71N 88W and 67N 88W seem to indicate that both the forelimbs and hindlimbs were being processed together. The concentration at 68N 90W is not close to any feature and like the forelimb concentration in occupation two, it is over a meter away from feature #28 but is associated with a number of projectile points. Unit 66N 91W is associated with hearth feature #31 while 71N 88W is located next to hearth #27. Unit 67N 88W is located between hearth feature #42 and hearth feature #43 and the concentration moves northward to define hearth features #42, #41 and #39. The concentration at 71N 94W does not seem to be related to any feature although the concentration expands to the south to feature #35.

Phalanges

The biggest concentration of phalanges in occupation one is in 68N 93W (Figure 11, Appendix II). This is related to the hearth feature #34 and overlaps with the forelimb and hindlimb concentrations near the hearth feature. Unlike the forelimb and hindlimb concentrations there is no associated concentration of phalanges at FCR feature #32. North of this cluster is a smaller area that has no nearby features but fits the generalized scatter of forelimb and hindlimb elements in the northwest portion of the block. There is

another small concentration at 70N 88W which is next to hearth feature #23. There is again a concentration of elements coming out of the southern wall of the block at 66N 91W which is not related to any features in occupation one.

The phalanx concentrations of occupation two were a little more difficult to interpret. The largest concentration at 68N 92W does not seem to be close any feature although the concentration in general seems to define hearth feature # 35 (Figure 12, Appendix II). The concentration at 68N 90W is also not very close to any features. The other concentration at 67N 87W is obviously related to hearth feature #42. It may be that the low utility of the foot of the bison resulted in it being discarded away before the rest of the limb was brought to a food processing area around the hearth.

Sesamoids

Occupation one only has one concentration of sesamoids of any note (Figure 13, Appendix II). 68N 94W corresponds to the hearth feature #34 and the forelimb and hindlimb processing area on the west side of the hearth. The other small concentrations at 70N 91W and 71N 93W are not related to any feature and fall into the generalized faunal disposal/ caching area.

Occupation two concentrations of sesamoids are also very low (Figure 14, Appendix II). The concentrations at 68N 92W and 70N 91W seem to define the eastern edge of feature #35 and may be related to fore and hindlimb processing there.

5.5.2 Canid distribution

Vulpes velox

The concentration of swift fox material in occupation one is low. The threshold was reduced to ≤1 in order for it to become visible. The low concentrations correspond to a few features such as the one around the southern margin of feature #34 (Figure 15, Appendix II). There are also clusters at features #20, #23, and #25. There are no significant concentrations of swift fox in occupation two.

Small *Canis sp.*

Occupation one yielded no concentrations of small canids materials. Occupation two had several but they were all of low density (Figure 16, Appendix II). The remains are associated with feature #35 and #31. There is also a concentration at 71N 93W which corresponds to a large area of ash, possible a dump from another hearth outside of the excavation area.

Medium *Canis sp.*

The indeterminate medium canids encompass a group that falls in between the size of coyote and wolf. This includes the immature canid remains found at the site. Occupation one does not have any clusters of this material. Occupation two has one small cluster at 67N 92W, this is next to feature #31,a small hearth.

Large *Canis sp.*

The large canids had a large concentration in the northwest section of occupation one of the block excavation (Figure 17, Appendix II). The size of the domestic dogs in

the Late Prehistoric make it likely that this concentration represents both wild canids and domestics at the site. The concentration is the result of several individuals although there was a large number of arthritic remains in the area that may represent at least one nearly complete canid. This large concentration does not seem to be associated with any hearth feature. Part of the concentration touches the edge of the small hearth at 69N 94W but does not seem to have any solid connection. There is a concentration of projectile points that seems to correspond to the southwest to northeast pattern of the large canid concentration. It may be that this was an area for the disposal of butchered remains There was also a smaller concentration at 68N 93W, which corresponds to hearth feature #34).

Occupation two has one major concentration that seems to be associated with feature #42, a fairly large hearth that is bisected by the southern trench wall (Figure 18, Appendix II). There is also a smaller concentration around feature # 31, a hearth feature much smaller in area than feature #42).

5.5.3 Rodent distribution

In occupation one the rodent bones are clustered around 70N 94W (Figure 19, Appendix II), near an area of oxidized earth in unit 69N 94W. The high concentration is based on a large NISP with a low MNI. These may represent most of a single individual and the high degree of burning exhibited on the limb elements may indicate that the carcass was burned too thoroughly for consumption during cooking and disposed of in the unit. Although not identified as a hearth in the level records, the area of oxidized earth

may represent a small expeditious event that was used for the cooking of small rodents. This would have resulted in a low impact hearth that did not initially seem to elicit notice. The level two rodents are associated with feature # 42 (Figure 20, Appendix II), the "Gray Ash Hearth". There are other concentrations but of such a low level (≤1) that they could easily be the result of scatter.

5.5.4 Avian distribution

Anatids

Although there are a number of avian species at the site the most numerous are the anatids, or migratory water fowl. The largest concentration in occupation one, based on NISP, (Figure 21, Appendix II) centers around unit 68N 93W. Feature # 34, located around the same unit, is described as an area of burned earth and ash. The other concentration centers around unit 70N 90W, although this area of burned earth was not assigned a feature number is seems to represent at least one small hearth feature that was associated with the preparation and cooking of some of the birds at the site. The occupation two anatids are concentrated in 69N 91W (Figure 22, Appendix II) but there is no feature closely associated with them. The nearest is feature # 35, an ash dump, which is about one meter away. This may represent a disposal area for both fire ash and carcasses.

5.5.5 Conclusions

The distributions indicate a number of discrete activity areas existed within the upper and lower occupation levels of block seven west. Most of them define the hearth

features that are present throughout the site. There are a few patterns which not only define the features but also indicate the activities that were being carried out around those hearths. In occupation one it is obvious that hearth #34 was a primary processing area for both fore and hindlimbs on the western side of the hearth. The limbs having been stripped of their meat and low utility portions, such as the feet, were moved to the FCR concentration at feature #32 where they were processed for marrow and grease. The lack of any phalanges around feature #32 indicates that the limbs had already been segmented while the lack of sesamoids indicates that they had either been removed with the phalanges or when the meat from the back of the leg was stripped. The concentration of projectile points, bone and no recognized feature in the northwest portion of the block indicates a disposal area for carcasses or a cache for meat. Ethnographically the discarded portion, of the bison were often located near cached meat so the concentration may represent both of these events (Wilson 1924:251).

Occupation two also indicates a number of activity areas that were centered around the identified hearths. As in occupation one, the fore and hindlimb elements were often clustered together, and there was separation between these elements and the phalanges and sesamoids. The separation was not as obvious as in level one but it is apparent that both levels had discrete areas for the processing of the bison.

The clustering of the elements in both occupation levels indicate that the site was likely not disturbed by the flooding of the nearby river. Strong water currents could have created clusters by pushing bone portions into depressions and lees in the river flow but

these clusters would not have been located next to the hearth features and would have been composed of a mix of all the bone elements found at the site. It also indicates that the butchering of the animals was very close to the kill area. Had the material been carried in from a kill site outside of the excavation area only the high yield portions of the animal would have been found in the processing area. This interpretation is supported by the presence of articulated limbs and vertebrae which were never processed.

More importantly, the concentrations of elements around the hearths indicate that the site was not heavily affected by carnivore activity after the initial processing. Most of the elements do not exhibit signs of carnivore chewing but that is not always a good indicator that carnivores, specifically canids, did not impact the site (Kent 1981:372). It is important to determine that the patterns at the site are the result of human and not canid behavior. Canids could easily have created some of the concentrations and scattering at the site as well as removed large numbers of elements for consumption elsewhere. As the concentrations are associated with cultural features and most of the bison elements are well represented, it seems likely that most of the distributions were the result of human activity.

It is difficult to determine the relationship of the hearths based on the distribution of the remains. The existence of only one species of animal at one hearth and a totally different one at another are likely not the result of specialized hearths but different procurement events. The site would then have had several occupations that formed it. This has resulted in several events being superimposed on one another but having been

separated temporally by months or even years. It is also possible that the remains found in block 7 west that did not seem to have any feature association are not necessarily related to the features in that same block. The processing areas of the Ruby site, 48 CA 302, in Wyoming were up to 900 feet away from the kill site (Frison 1971:86) indicating that secondary processing can be quite spread out in the archaeological record. In an ethnographic study of the Hadza hunter gatherers of Africa several large mammal butchering events were analyzed and recorded in an attempt to determine patterns in distribution. Several large ungulates were killed in ambush or scavenged and were then disarticulated and processed. Some of the hearths associated with their processing were up to 35 meters away from the animal (Connell et al 1992:325). Any direct links between the hearths would not be possible without evidence that they had been formed at the same time. The refitting of lithic and faunal material might provide this kind of evidence.

The separation of the concentrations between the two occupation levels seems to be quite good. There are some concentrations which seem to overlap but most of these are minor or can be explained by hearths being located within the same area in both the upper and lower occupations. It is likely that some mixing must have occurred between the two layers as the digging of pit hearths in the upper level, the difficulty in recognizing the sterile gray clay layer in some units, and faunaturbation would have all contributed. In a study of a site in California, Erlandson (1984:788) calculated an average 5% redistribution for every century as the result of burrowing animal activity. Despite these

factors the site has still maintained enough integrity for the faunal distributions to be recognizable.

5.6 Seasonality and Bison Herd Age Structure

The faunal assemblage of the Sanderson site provides the best evidence for determining the season of occupations. There are a number of physiological processes, such as tooth eruption and wear as well as fetal bone formation and growth, that follow a predetermined time table in the life of the bison. Determining when those processes were stopped is the key to determining the time of the year the site was being utilized. There are also a number of behavioural patterns which can help to determine the seasonality of the site. Many of the mammals at the site had distinct hibernation patterns and several of the avian species follow a set pattern of migration that would have placed them at the site at certain times of the year. Besides the faunal material there are many plant species at the site which follow a set schedule of growth, flowering and seed formation. The combination of these elements can determine if the seasonality of the site was restricted to a short period of time or if a long term occupation is more likely to have formed the material there.

5.6.1 Bison Dentition

The eruption of the tooth row in bison follows a predetermined schedule that can be used to establish the age of the animal. Once the tooth has erupted, the wear on the enamel of the tooth becomes another, although less accurate way, to determine the animal's age. The aging of the bison is based on a relatively short and consistent period

of birthing between the last part of April and the first part of May (Frison and Reher 1970:46). It is assumed that a cohort of bison born together and living together will share a similar pattern of eruption and dental attrition (Todd & Hofman 1987:495). The Sanderson site material was highly fragmented and there was only a small sample of dental material which could be analyzed. There were no complete bison mandibles recovered from either the upper or lower occupation at the site. The mandibles must have been broken during processing or during some later post-depositional event. Upper dental material was often fragmented and was not found within its alveolar sockets while there were more complete and socketed teeth found from the lower dentition. For this reason all of the material used in the analysis came from the mandibular dentition at the site. Four partial mandibles and fourteen individual teeth were used for analysis of the material from occupation one and seven individual teeth were used in the occupation two analysis. All of the mandibles were fully erupted and represent the remains of an adult population. There were fragmented remains of unworn molars but none of these teeth were located within the mandible. This meant that the level of wear might indicate separation of ages in the few adult teeth found but it was impossible to determine the exact time of death based on this alone. As a result all of the teeth were analyzed on the basis of their wear as outlined by Todd and Hofman (1987) and Frison (1982). The terminology of Todd and Hofman (1987) was used to describe the cusp morphology and dental wear patterns on the bison teeth from the Sanderson site.

The teeth were grouped based on the metaconid height but it was first necessary to define the groups. After the initial analysis it became apparent that the upper and lower occupation fell into the same attrition groups despite their small sample size. Designating an age group to this sample was a large problem. It became necessary to compare the level of wear to other samples in order to estimate the time of death. This is based on the false assumption that all bison teeth wear at the exact same rate between different populations of bison. The only reasonable assumption is that similar wear across two adult populations would result from similar seasonality but certainly not identical months. A number of large samples exist for the purposes of comparison including the Horner and Finley sites (Todd & Hofman 1987), the Vore site (Reher and Frison 1980), the Agate Basin site (Frison 1982), the Glenrock Buffalo Jump (Reher 1970) and the Heron Eden site (Corbeil 1995). The Sanderson site material matches the attrition exhibited at the x.6 time interval but due to the ambiguity of this method this material will be referred to as x.5-7. These comparative sites designate 11 age groups into which bison teeth can be grouped. Eight of the age groups were postulated in the Sanderson site material based on tooth wear and metaconid height. There were a number of gaps in the age groups, including group 1 (0.5-7 years), group 2 (1.5-7 years) and all groups above 6E (9.5-7 years).

Tooth wear is not as sensitive an indicator of seasonality as tooth eruption patterns (Frison 1982a:241). It may not be an accurate indicator of the age of the animal but it can give some indications about the number of age groups present within the population. If

these age groups tend to cluster together it is a good indicator of a restricted seasonality at the site and if not a single catastrophic kill, at least a series of smaller ones within a few months time.

Group descriptions

Group 3 (2.5-7 years)

This group consists of a single isolated tooth from occupation one. The exostylid of the M_1 is just beginning to wear.

Group 4 (3.5-7 years)

This group also consists of a single isolated tooth from occupation one. Cusps I-IV of the M_3 show wear while cusps VII and VIII show none.

Group 5 (4.5-7 years)

Only two specimens occur in this group and they are both M_1 from occupation one. In both the exostylid joins the enamel of the main part of the tooth.

Group 6a (5.5-7 years)

There are 5 specimens from occupation one and one specimen from occupation two. The occupation one specimens consist of two M_2's, one with its exostylid in wear and the other barely in wear (1mm). There are also three M_3s, all of which have their hypoconulid joined with the rest of the enamel. The occupation two specimen consists of a single M_3 that has its hypoconulid joined to the rest of the enamel.

Group 6b (6.5-7 years)

There are three specimens from occupation one and none from occupation two. Two M_1's are socketed with an exostylid that joins the rest of the enamel and an enamel root line that is above the alveolus. The other M_1 is isolated and has an exostylid that joins the enamel.

Group 6c (7.5-7 years)

This is the largest group represented in the sample, there are three isolated teeth and one partial mandible from occupation one and four isolated teeth from occupation two. In the occupation one group the M_1's exostylid enamel connects with the rest of the tooth. The M_1 enamel in the partial mandible is above the alveolus while the M_2 enamel is below the alveolus. The M_3 exostylids are in wear but are not joined to the rest of the tooth. In occupation two the M_2's have an exostylid that is joined to the rest of the tooth enamel and an enamel rootline that is below the alveolus. The M_3's have an exostylid that is in wear.

Group 6D (8.5-7 years)

There are only two samples from occupation one in this group, one partial mandible and one isolated tooth. The one partial mandible had M_1 and M_2 still intact in the jaw. The M_1 prefossette is worn off and the M_1 exostylid has joined the body of the tooth. The M_2 enamel is at the same level as the alveolus. The other member of this group was a isolated M_3 which has an exosytlid in wear.

Group 6E (9.5-7 years +)

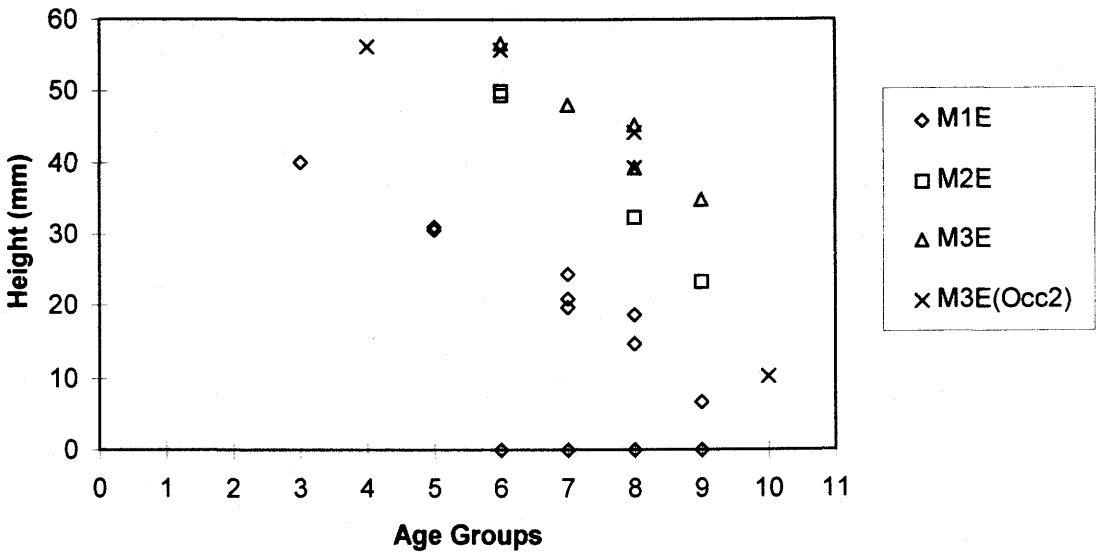
There is only one isolated tooth from occupation two in this group. The M_3 has an exostylid that is joined to the rest of the tooth.

As table 5.10 indicates there are not enough mandibles and teeth to present a complete profile for the purposes of calculating the mean rate of molar attrition. Figure 5.1 indicates a fairly even wear profile although it is necessary to be cautious with a sample size this small. Occupation one and occupation two samples were combined as the wear and age groups appeared to be the same, indicating an identical seasonality between the two occupations. Looking at the average attrition rates for larger archaeological samples the rates of 5.4 mm/yr at the Horner site (Todd & Hoffman 1987:518), 5.9 mm/yr at the Agate Basin site (Frison 1982a:250) and 5.7 mm/yr at the Heron Eden site (Corbeil 1995:76) the teeth at the Sanderson site have a similar rate of attrition.

Table 5.12 Mean molar metaconid height by age group of the combined samples from occupation one and occupation two.

Age group	Age in years	N M1	Enamel height	N M2	Enamel height	N M3	Enamel height
1	0.5-7	-	-	-	-	-	-
2	1.5-7	-	-	-	-	-	-
3	2.5-7	1	40.5	-	-	-	-
4	3.5-7	-	-	-	-	-	-
5	4.5-7	2	30.9	-	-	-	-
6a	5.5-7	-	-	2	46	4	54.9
6b	6.5-7	3	21.7	-	-	-	-
6c	7.5-7	2	16.7	3	33.4	4	42.1
6d	8.5-7	1	6.7	1	23.3	1	34.9
6e	9.5-7+	-	-	-	-	1	10.3

Figure 5.1. Comparison of metaconid heights for occupation one and two.



5.6.2 Summary

The seasonality of other sites with similar wear patterns and metaconid heights indicate that the x.6 increment for age groups is valid. The seasonality for those sites based on a birthing season from April 15 to May 31 would be sometime during mid-winter, probably December or January. Both occupations share the same wear patterns although the sample from occupation two is very small. At the very least it indicates that the site had been used as a winter kill site for at least two separate occupations and that some of the patterns found in the first occupation should be quite similar to those patterns found in the second occupation.

There was a noticeable gap in the lower age groups based on the mandibles and teeth found at the Sanderson site. The lack of any age categories from the younger

animals is not unusual at kill sites (Speth 1983:71). It is usually a reflection of susceptibility to decay and the ease with which they can be transported from the site. The existence of immature limb elements indicates that the younger age groups were in the assemblage but they simply did not show up in the dentition analysis. The lack of these younger animals in the analysis has resulted in a single concentration of older animals. This is similar to the age profile of the Glenrock Buffalo Jump where the same profile occurred. This was interpreted as a single catastrophic event which would have exhibited a normal distribution for catastrophic mortality had the immature elements not been removed from the site (Reher 1970:53).

Both the occupation one and occupation two closely resemble one another in age group profile which is why they did not produce any bimodality when they were combined. This would seem to indicate similar mortality profiles and therefore similar hunting strategies were being used in the two separate kills. Caution must be taken though, as the Sanderson site profile is based on a very small sample.

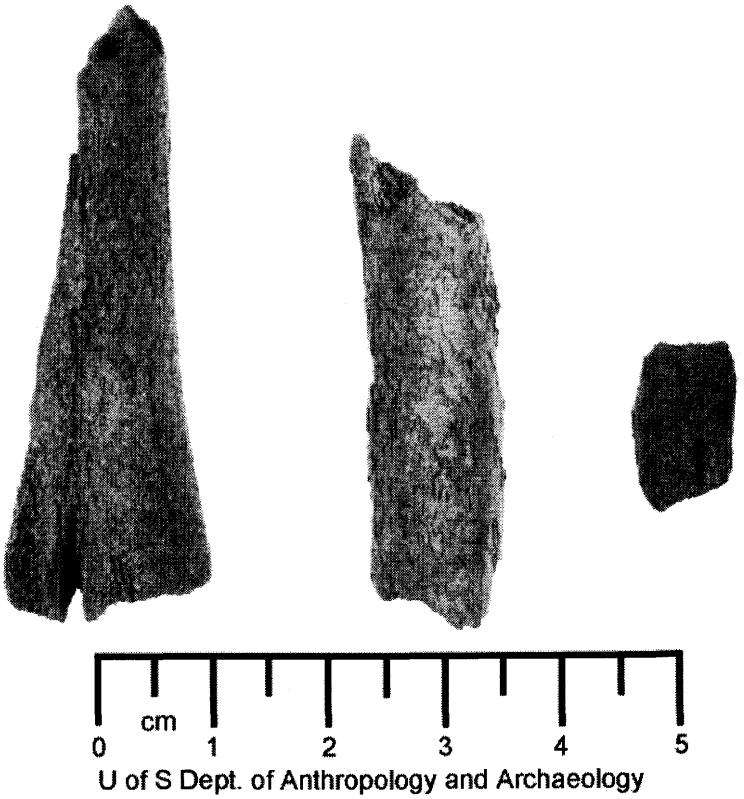
5.6.3 Fetal bones

There were a number of fetal remains found at the Sanderson site. Unfortunately most of them were fragmented and it was therefore difficult to determine their stage of development. Wilson (1974) developed a method of aging the fetal skeleton based on multiple measurements and periosteal layering. Unfortunately none of the limb elements used in this method showed up in a complete enough form at the Sanderson site. Periosteal strata have also been used to determine fetal age. Again, the sample is too

small and fragmented to compare with McKee's (1985:35) periosteal data from the River Bend site. The metapodial shafts are the most recognizable and the most common element that survived in the assemblage at the Sanderson site (Figure 5.2) . The bone had not reached the stages where the epiphyses had started to ossify so only the shaft of the bone remains. The metapodials begin as two halves that slowly fuse and both fused and unfused metapodial halves occurred in both occupation levels.

The third and fourth metacarpal and metatarsal bones of the fetal bovine begin to ossify at 58 days (Lindsay 1969:104). This would only be a small diaphyseal ossification

Figure 5.2. Fetal metapodials from the Sanderson site.



loci which would spread proximally and distally to form the two halves of the metapodials. The metapodial halves begin to fuse together in the last two months of gestation (Wilson and Davis 1978:324). Based on a conception date on late August/ early September, this would date the fetal material at the Sanderson site at early November to early March.

5.6.4 Immature bones

There are a number of immature bones, based on size and unfused epiphyses, in both occupation levels of the Sanderson site. As fusion can occur in some bones as late as the eighth year for such bones as the pelvis, ribs and scapula and can vary by several months depending on the individual, it is often not a reliable indicator of exact age (Koch 1935:373). The variability of fusion may eliminate it as a method of determining seasonality but the size of the immature bones in the first year of growth may provide clues about the age of the animal when it died. Growth occurs in male European bison up until their sixth year while growth occurs in the cows up until their fourth year (Koch 1935:372). The length of growth of the male bison is likely related to sexual dimorphism and their overall larger size.

With this in mind it may be possible to compare immature elements from a comparative collection with the immature elements at the Sanderson site. If the materials compared are under four years of age, differences caused by the termination of growth should be minimal. Therefore the one nearly complete immature element from the Sanderson site, a metacarpal (Figure 5.3), was measured to determine its relationship to

the comparative collection at the University of Saskatchewan (Figure 5.4). The results

Figure 5.3. Immature metacarpal from the Sanderson site.

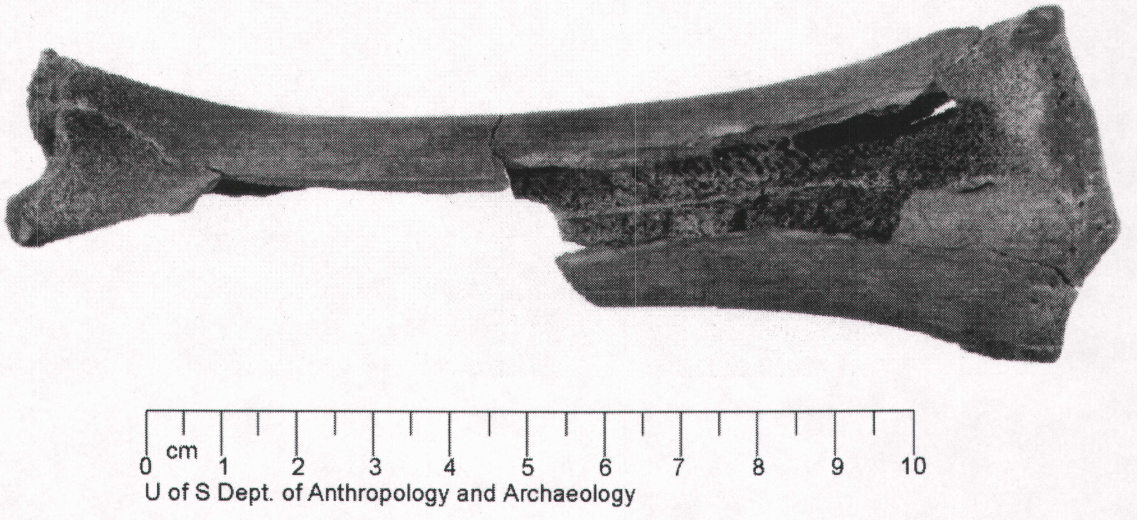
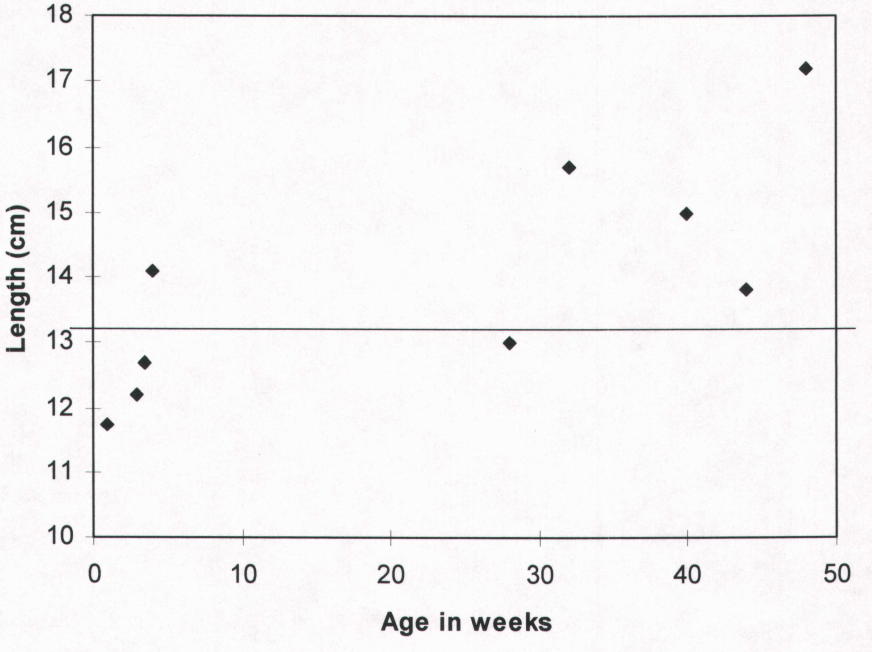


Figure 5.4. Comparison of metacarpal shaft lengths with age. Dotted line represents the shaft length of Sanderson site material.



are ambiguous, as there does not seem to be constant rate of growth exhibited among the bison in the comparative collection. The length of the Sanderson site metacarpal would fall between 4 and 30 weeks, a relatively large time frame.

5.7 Seasonality from other faunal sources

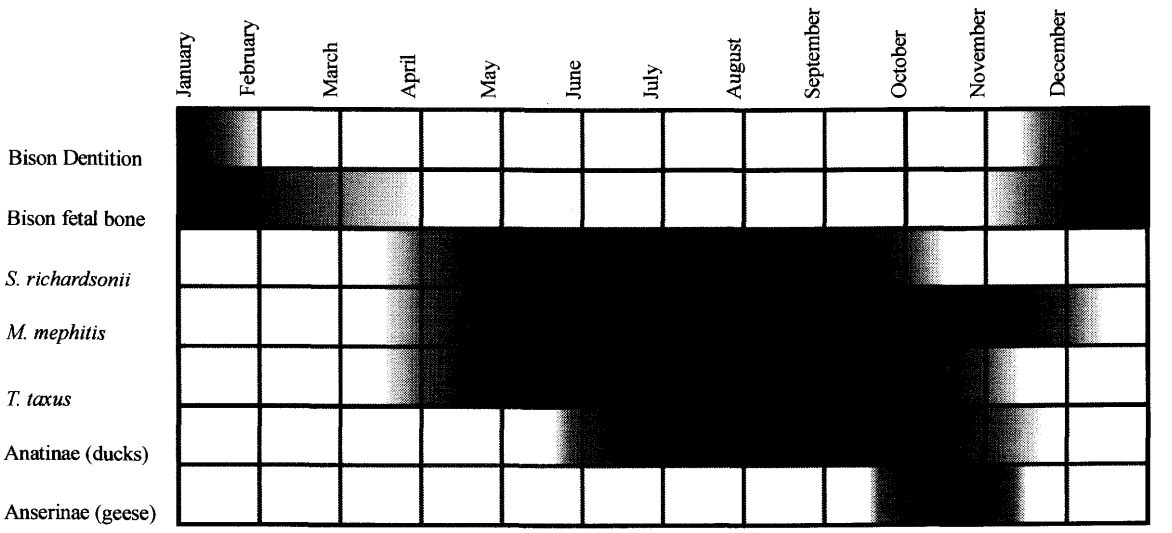
Bison is not the only animal which provides information about the seasonality of the Sanderson site. A number of the other animals found at the site are only there during a seasonal migration round, and others spend part of their year in hibernation. Using these data will increase the knowledge about not only the season during which the site was occupied but the duration of that occupation.

There are a number of small mammals found at the site which hibernate during the winter. Only those that were considered contemporaneous with the site were included in the summary. The Richardson's Ground Squirrel hibernates from the start of September to the middle of October and usually re-emerges in mid March (Banfield 1977:115). Skunks also hibernate through the winter from early December to late March (Banfield 1977:340). There are also a number of larger carnivores represented in the site. Most of these would not have been seasonally restricted but the badger does hibernate from November to April.

The number of migratory waterfowl is enough to give some indication of the seasonality. Some such as the Canada goose could occur in southern Saskatchewan year-round and were therefore not included in the seasonality summary. Both the Blue-Winged Teal and the Mallard duck move into the Estevan area in the spring and lives

there throughout the summer finally leaving in the fall. As Figure 2.7 indicates the modern Mallard population peak occurs in the middle of October. None of the migratory birds exhibited the thickening of the medullary bone that is associated with egg laying in the female population (Driver 1982:252). Most of the bones were fragmented so X-rays and bone sections were not necessary for this investigation. This only indicates that none of the birds were springtime egg laying females. Figure 5.5 presents a summary of the faunal seasonality indicators.

Figure 5.5 Summary of restricted seasonality of Sanderson site faunal elements



5.8 Seasonality from ethnobotanical sources

Plant macrofossil analysis at the Sanderson site yielded a fair amount of charcoal and many seeds were also found, a number of them charred. These included goosefoot (*Chenopodium sp.*), knotweed (*Polygonum sp.*), dock (*Rumex sp.*), marsh elder (*Iva sp.*), bulrush (*Scirpus sp.*) and others (Shay et al. 1990:10). Of these plants the most common and abundant seeds were goosefoot and stinging nettle (*Urtica dioica*). Goosefoot

occurred on average in about half the sample and made up over 50% of the total number of seeds (Shay et al. 1990:100).

Of the eight sites compared from the area the Sanderson site was among the top three for abundance and diversity of plant resources found. It also had the greatest variety of resources, likely due to the extensive marsh adjacent to the site (Shay et al. 1990:100).

Berries and fleshy fruits were also represented in the Sanderson site recoveries. These included Wild cherry (*Prunus sp.*) and wild rose seeds (Shay et al. 1990:41). Wild rose seeds were the most common at the Sanderson site among the fruits and berries.

In comparing the plant remains of the Sanderson site to the Late Prehistoric occupation (Old Womens's Phase and Historic) at Tipperary Creek (FbNp-1) there were a number of similiarities. The seeds of weedy annuals were found at both sites, with goosefoot having the highest frequency at both sites. The most popular fruits and berries were wild rose and wild cherry (Shay et al 1990:102).

Discussion

Goosefoot was used as both a source of greens during the summer season and for its seeds later in the season (Turner 1981:2335). The seeds of the stinging neetle has not been recorded as a plant food resource (Turner 1981:2342). It was eaten as a green so as the plants had already gone to seed it is likely that they were being processed for their fiber rather than the food value of their seeds (Shay et al 1990:101).

The plant resources at the site would have provided a supplement to the protein resources of the local fauna. The importance of a carbohydrate source during winter

subsistence is extreme. Although fat from pemmican and soup making would help to avert protein poisoning, carbohydrates, which can only be obtained from plant resources, become much more effective in the processing of protein later on in the season (Speth & Speilman 1983:13).

The seasonality based on the seeds found at the site would be the late summer or early fall. This is consistent with the restricted seasonality of some species in the faunal assemblage. It is most likely that people were moving into the area during this part of the year in order to take advantage of the rich plant and animal resources of the nearby marshlands and wooded coulees. This would have provided an excellent way to stockpile supplies and prepare for winter at the site.

5.9 Bison population sex structure

Sexual dimorphism in bison refers to the size differences between the male and female. The average weight of a bull is 570 kg while a cow weighs about 420 kg (Banfield 1977:405). This difference has lead to a number of methods being created to infer sex ratios in archaeological bison populations.

Unfortunately most of these methods rely on complete elements and the Sanderson assemblage has suffered a high degree of fragmentation. The use of skulls and complete long bones was not possible as there were none recovered intact at the site. The use of fragmentary remains can cause biases in the apparent age structure. The condition of the last fusing epiphysis cannot be determined in a fragmented bone, so a first-fusing epiphysis that gives small measurements could represent a small, mature female or a

small, immature male (Speth 1983:79). Any fragmentary remains that fall into the larger male range do not have to be questioned, but there may be a bias in favour of recognizing bulls.

5.9.1 Carpals and tarsals

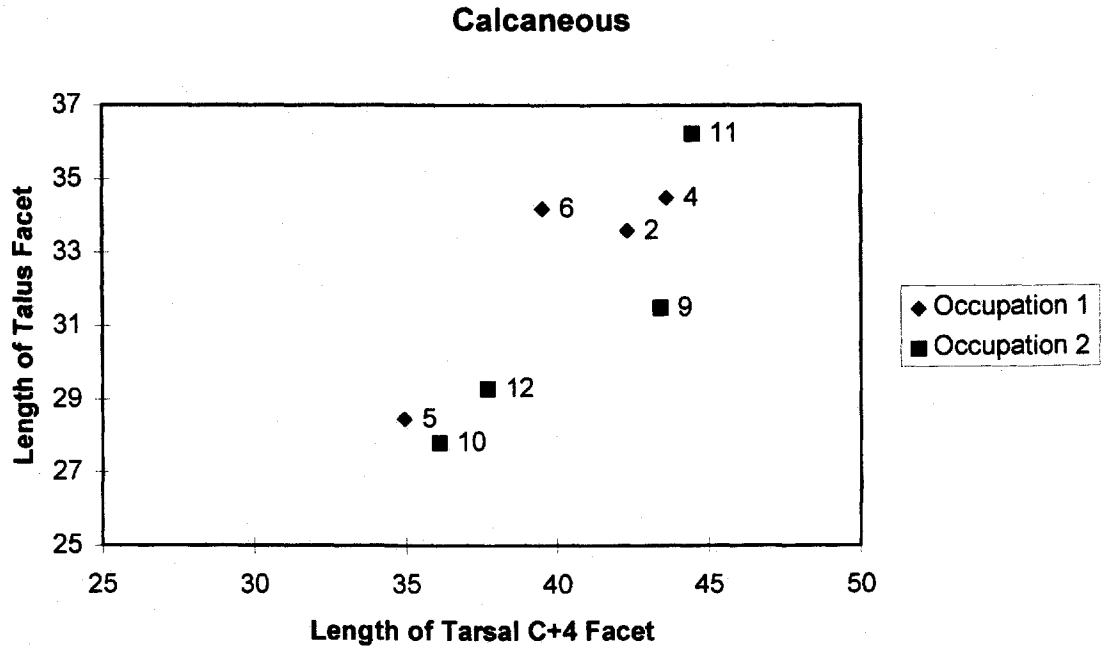
Even in a highly fragmented archaeological assemblage the high density and low utility of the carpals and tarsal usually leads to a high survivability for these elements. These elements are often the only measurable bones left at an archaeological site where the bison were subjected to marrow extraction, grease manufacture and carnivore action (Morlan 1991:215) A number of methods have been created to take advantage of this phenomenon. The problem with the use of these elements in the sexing of bison populations is the inability to distinguish mature from immature elements. With the exception of the calcaneus, none of the bones have observable epiphyses (Morlan 1991:215).

The Sanderson assemblage not only has a high degree of fragmentation within the long bones but also among the carpals and tarsals. As a result measurements were made on refitted bones and often could not be made at all. Morlan (1991) defined the measurements and methods used on the sample.

The calcanei provided the best separation between males and females in both occupation one and occupation two, specifically a bivariate plot of the length of the talus facet (Lt) and the length of the tarsal C+4 facet. Based on this method there were three males and one female in occupation one and two males and two females in occupation two (Figure

5.6). There was one immature specimen from occupation one, but it was too fragmented to obtain the necessary measurements. Although there seems to be grouping occurring in the Sanderson site material the size of the sample requires that a certain amount of caution be exercised before any firm conclusions can be made.

Figure 5.6 Bivariate plot of calcaneus measurements for occupation one and occupation two.



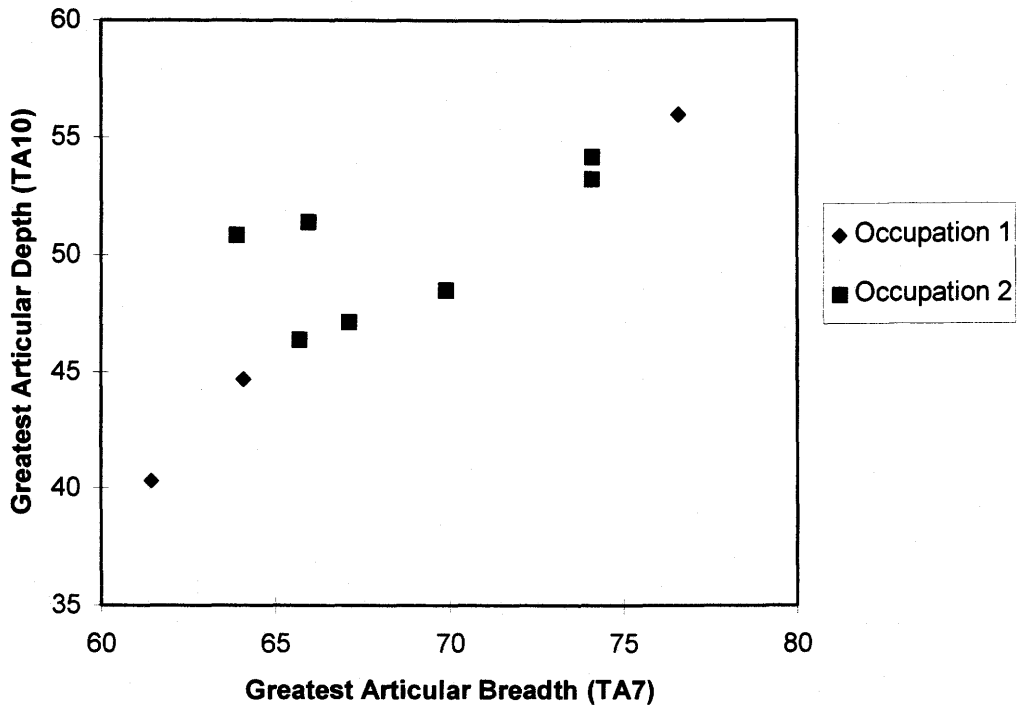
5.9.2 Long bones

Certain long bone measurements can be used to infer sex in archaeological bison remains. They would allow for comparison with other bodies of data (Todd 1987b:372), and they were designed to accommodate common breakage patterns which were prevalent at both the Sanderson site and the Horner site.

Even with multiple measurements that were meant to deal with fractured bone the Sanderson site yielded a limited number of valid measurements. The forelimb elements were represented by no proximal humerii in either occupation and five distal humeri in occupation one and three in occupation two. There was one proximal radius in occupation one and four radii in occupation two while there were two distal radii in occupation one and none in occupation two. The hindlimb elements were represented by one proximal femur in occupation two, none in occupation one and no distal femora in either occupation. There was no proximal tibia in either occupation, while there were four distal tibiae in occupation one and eight distal tibiae in occupation two.

The most numerous elements, distal tibiae, were subjected to a bivariate plot but the data could not be compared with that from the Horner site as the species of bison at that site, *Bison bison antiquus*, was larger than modern bison (Todd & Hofman 1987:495). Although all of the distal tibiae from the Sanderson site were completely fused, it is not possible to assess the degree of fusion of the last fusing proximal epiphsis. The distal tibiae clustered into two groups (Figure 5.7), presumably representing seven females and three males. Five of the females were from occupation two, while two of the females were from occupation one. Two of the males were from occupation one while the only other male came from occupation one. All other distal tibiae were too fragmentary to assign to the groups once they had been identified. The lack of a comparative sample of measurements from bison of known sex makes it difficult to ensure that the separations are due to sex and not a size gap within the same sex.

Figure 5.7 Bivariate plot of Sanderson site distal tibias.



5.9.3 Summary of sex

Traditionally it has been considered that late August was a period of aggregation of large mixed sex herds of bison drawn together for rutting and breeding bison. After the rut their pattern of dispersal is more debatable. In September some of these large herds would split into smaller groups, one called a nursery herd comprised mainly of female bison and their offspring, both male and female, and the other containing mature bulls (McHugh 1958:14). There were also groups which would aggregate on their winter feeding grounds, forming large sedentary herds (Arthur 1975:242).

Table 5.12 gives a summary of the sex composition of the two occupations at the site. The mixed sex of the bison remains would seem to indicate a herd from the rut season of August but all of the other seasonality indicators do not point to this time of the year. It is also possible that there were two separate kill events, one of a nursery herd and another of a bull herd later on in the season. The last possibility would have been serial predation on bison in the area. This would lead to a series of small kills throughout the season. It is likely that the herd composition was affected by a number of different factors. This is based on a growing belief that herd aggregation and dispersal is not simply a function of season and social factors but a number of ecological and environmental factors as well (Morgan 1980).

Table 5.12. Summary of *Bison bison* sex information from the Sanderson site

	Calcaneous		Tibia	
	Occ 1	Occ2	Occ1	Occ2
Male	3	2	1	2
Female	1	2	2	5

The richness of forage and water resources governed the migration and aggregation of the herds during the entire year. One resource rich area is the riverine ecotone whose shelter and food sources would have sustained the bison during the harsh winter months. The Sanderson site locality provided the sheltered coulees and woods as well as the required food and forage. Ethnographic data supporting this comes from Peter Fidler's eyewitness account of large, sedentary herds residing in sheltered areas such as woods, valley bottoms and coulees during the winter months (MacGregor 1966). The

reliability of the resources is demonstrated by the use of the site over an extended time period and multiple occupations. It is then likely that there were aggregations of bison herds within the river valleys surrounding the site. The rich resources of the area may not have promoted the separation of the herds into sex specific units but rather large mixed sex herds prevailed. It was, therefore, not uncommon to have large mixed sex herds occurring during the winter and in fact there are ethnographic accounts of pounding a mix of male and female bison in the month of December (Arthur 1975:238). This idea has received support from Dodge and Syms (1977:25) who both believe that although males may have occasionally nucleated off of a larger group the herd structure remained a mix of sex and age. The mixed sex at the Sanderson site, therefore, cannot be used as a determiner of seasonality. The possibility of attritional kills of both bull, nursery or mixed herds over the winter would provide one explanation of the mixed sex of the herd. A single catastrophic kill would provide the same sex profile and is therefore equally as valid a scenario. The resource dependent herd aggregation of bison during the fall/ winter months in the area make any conclusions about the nature of the kill impossible.

5.10 Pathologies

There are a number of pathologies that showed up in the Sanderson site faunal assemblage. These were not restricted to the large bison assemblage but are apparent in many of the other animals as well. The pathologies were analyzed by visual inspection and subjected to faxitronic imaging, a high quality radiograph, in order to assess their internal structure. The discussion of the possible causes of the pathologies included a

summary of existing literature and consultation with Dr. Charles Farrow of the radiology department at the Western College of Veterinary Medicine, Saskatoon.

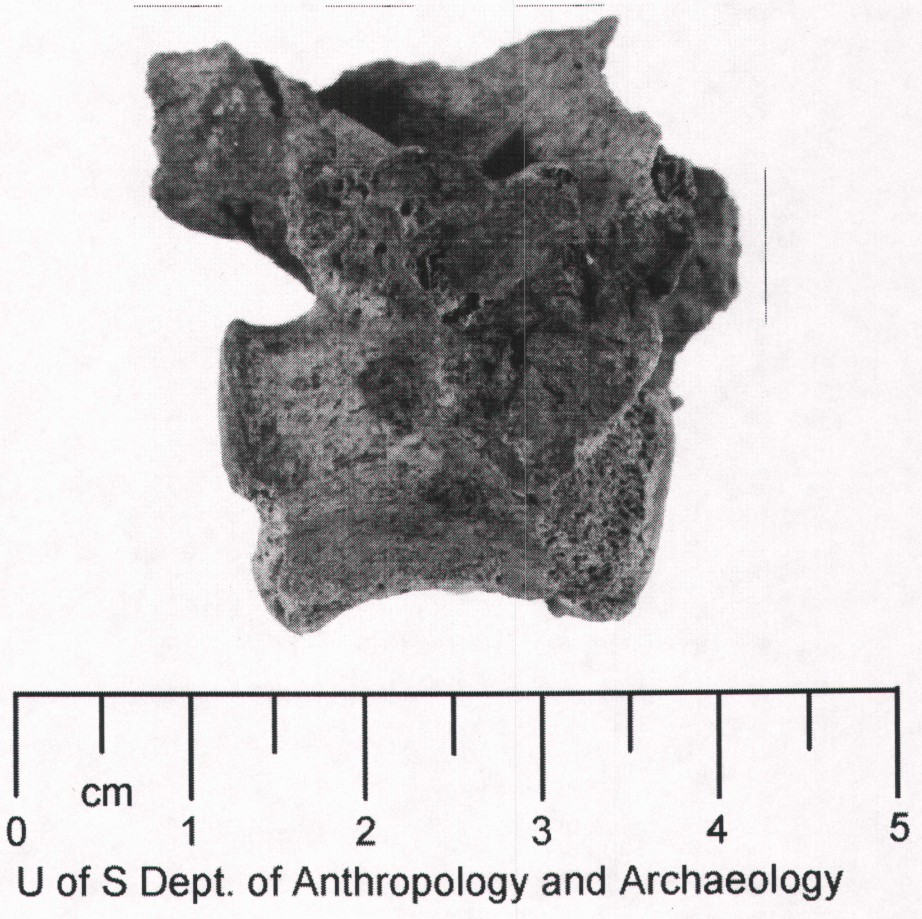
There were numerous instances of osteoarthritis and eburnation of articular surfaces among the bison sample but this was not unexpected due to the extreme age of some of the bison as indicated by the dental age groups. One of the most extreme examples was a calcaneus (68242) (Figure 5.8) that had eburnation on the lateral malleolar articular surface and extensive osteophyte growth on the lateral aspect of the distal calcaneous.

The eburnation of the contact surfaces of an articular joint and the formation of marginal exostoses around the periphery are symptoms of osteoarthritis (Lichtenstein 1975:283). This condition usually occurs when the cartilage protecting the articular surface has been worn down through use or damaged through injury or disease.

Osteoarthritis also occurred in the canid sample of the assemblage. One of the best examples is a thoracic vertebra (69199) from a large canid (Figure 5.9). There were a number of arthritic vertebra found in association with this particular specimen. This particular vertebra was from the last four thoracics of the spine. There is extensive degeneration of the joint surfaces on the costal facets, the transverse processes and the cranial and caudal articular surfaces. Accompanying this degeneration is osteophytic formation around the margins of these surfaces. These kinds of spine deformations are

Figure 5.8. *Bison bison*, arthritic calcaneus (68242), Sanderson site.

Figure 5.9. Large *Canis sp.*, arthritic thoracic vertebrae (69199), Sanderson site.



common in pack animals and have shown up in other assemblages where dogs were used to carry loads (Hayden 1997:98).

There is also an occurrence of periosteal ossification in a large *Canis sp.* third metacarpal (67559) (Figure 5.10). The extension of the new bone deposition all the way to the subchondral margin of the bone is extremely unusual (Farrow: personal communication). Periosteal stimulation usually occurs when the periosteum is lifted or torn away from the surface of the bone (Lichtenstein 1975:248). It results in a new area of bone being formed beneath the membrane, laying a new layer over the bone. There are

a number of different diagnoses possible including: penetrating and blunt trauma, bone surface and contiguous infection or inflammation of bacterial and fungal origin, transient devascularization, inoculating wounds, and deep foreign bodies as well as some kinds of systemic infection (Farrow pers. comm., Simon 1973:78-84) It shows up as a periosteal shadow on a radiograph (Figure 5.11).

The only other pathology of note is the rib head and tubercle from a bison (Figure 5.12). This specimen (74523,74537) is made up of a large oval bone cavity that is approximately 2.5 X 4.0 cm. The cavitation is smooth walled, and the exterior is relatively free of new bone growth. The radiograph of the area (Figure 5.13) reveals that the bone structure of the surrounding bone is dense and healthy, indicating that the cause of the lesion was likely localized and encapsulated by the cavitation. Differential diagnosis of such a lesion is another difficult task, especially due to the fragmentary and incomplete nature of the specimen. It is common to come across simple cysts of uncertain etiology in human bones which do not appear to have any cause (Simon 1973:118), but bone cysts are rare in cattle and therefore unlikely in bison as well (Farrow per. comm.). A non-specific bacterial or fungal infection could also have created the cavity in the rib. A chronic infection would lead to the formation of a localized cavity, or involucrum, within the bone. The tissues of the body deal with infections that cannot be eliminated by sealing them away from healthy tissue. Other sources of cavitary bone lesions include fibrous displasia as well as primary and secondary tumors. There is also the possibility of an aneurysmal bone cyst although these are commonly full of loculated

Figure 5.10. Large *Canis sp.*, third metacarpal (67559) with periosteal ossification, Sanderson site.

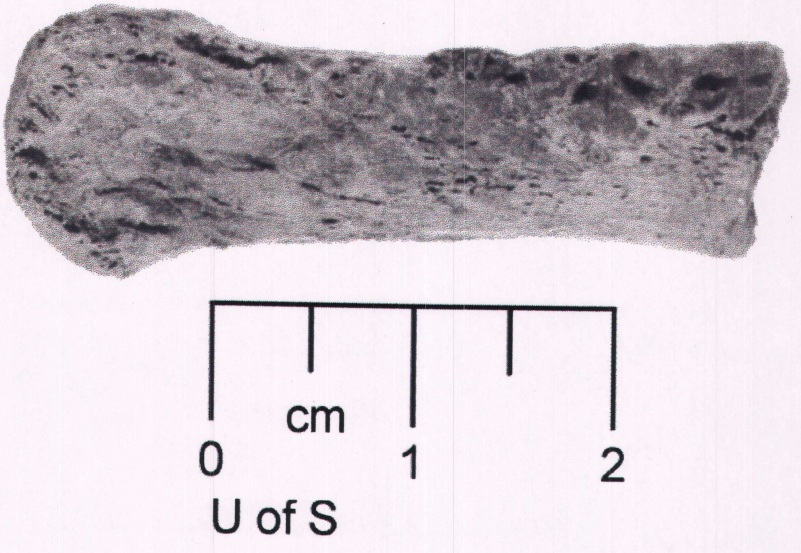


Figure 5.11. Large *Canis sp.*, radiograph of third metacarpal (67559) with periosteal ossification, Sanderson site.

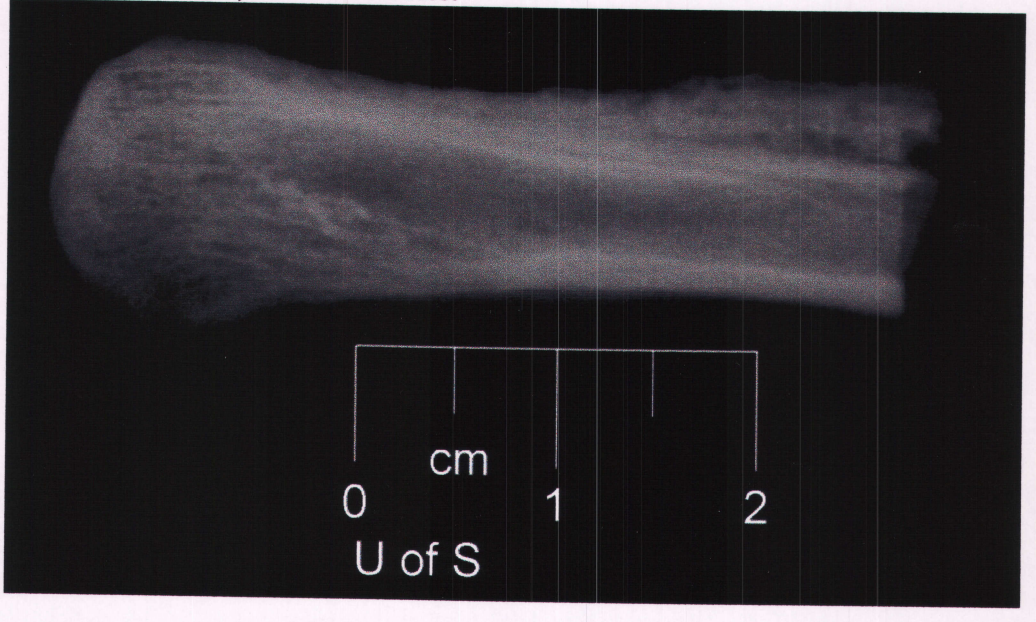
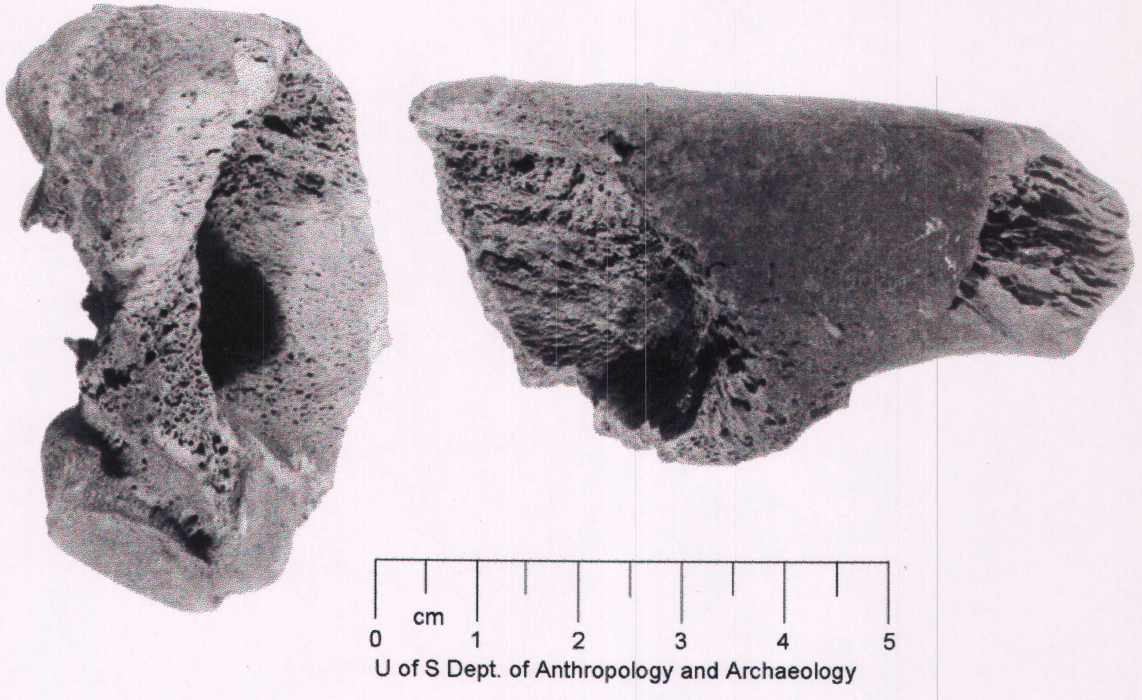
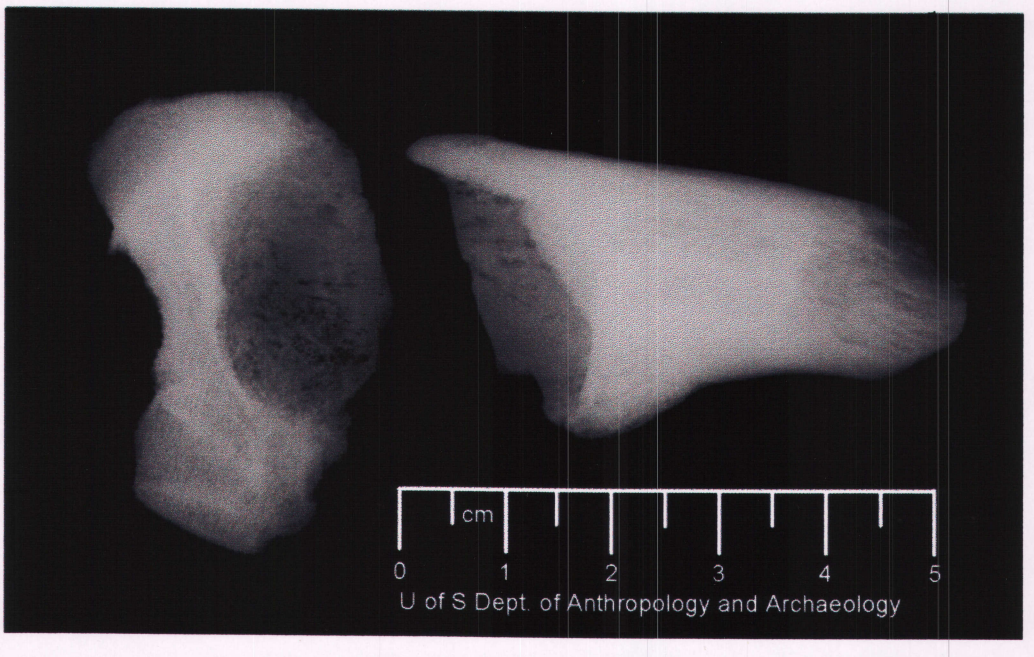


Figure 5.12. *Bison bison*, rib head with bone lesion (74523,74537), Sanderson site.



5.13. *Bison bison*, radiograph of rib head with bone lesion (74523,74537), Sanderson site.



chambers which this particular cyst lacks (Gilmer et al 1963:40).

Most of the pathologies exhibited at the Sanderson site do not represent anything unexpected in the faunal assemblage. They reflect the harsh living conditions endured by most animals on the Northern Plains where traumatic injuries were common and life expectancies were short due to the accelerated aging caused by this difficult environment. This includes most of the osteoarthritis seen in the bone. The periosteal reaction on the canid metacarpal was somewhat unusual due to its penetration into the bone and its reactive nature. The cavitation on the rib of the bison was also unusual as cysts do not often form in bovines although there are a number of possible causes.

5.11 Summary

The Sanderson site faunal assemblage was dominated by the sheer amount of *Bison bison* material, but this ungulate was far from the only animal recovered from the site. The MNI of all the animals was summarized at the beginning of the chapter so a detailed summary would only be redundant. With the exception of some leporid material from the upper levels, all of the material was considered to be contemporaneous with the site at the time of its formation. This does not mean that every bone was there as a result of human activity, Rather a combination of natural and cultural events may have occurred at the site.

The age profile of the bison assemblage indicates a grouping at x.5-7 years for both occupation one and two. Within this age profile is a distinctive gap in the lower age groups. The sample used in the aging was small but the degree of wear in all of the teeth

seemed to coincide with the annual enamel attrition rates seen in other bison assemblages. This would indicate a seasonally restricted kill site which based on a birth season of late April/ early May, would place the kills of occupation one and two in late November to late January. This fits well with the hypothesis that bison pounding occurred in the late fall/ early winter after the rut. These activities could continue throughout the entire winter well into the spring. Arthur (1975) presents a number of historical accounts of bison pounds being used through the winter up until April.

Much of the other faunal material does not have a restricted period of occurrence. Some were restricted to a spring, summer and fall period by such factors as hibernation and migration. The exclusive late fall occurrence of some of the large migrating birds provides a definite indicator of seasonality. The botanical resources also indicate a fall period of occupation. It was likely that people were moving into the valley during the fall to take advantage of the rich resources of the forest and wet meadows and then camping for the entire winter during which bison hunting occurred. The spring time would have brought flooding and wet conditions to the valley. With the faunal resources depleted and the bison herds moving back out onto the open prairie the people living there would have left as well.

Sex analysis indicate the males and females were almost evenly matched in occupation one while there was a slightly higher number of female bison in occupation two. This represents mostly mature animals although the fragmentary nature of the

material makes it possible that some of the females indicated in the analysis were actually immature males.

This is still consistent with a late fall/winter occupation. Traditionally it is believed the winter was a period when native peoples moved off the grasslands into the sheltered parklands. There is a growing belief that this was not necessarily true, rather there were some groups who chose to stay out on the plains and could depend on the bison populations there (Malainey & Sherriff 1996). There is even some evidence that there were preferred winter hunting ranges for bison which encouraged people to stay out on the prairies and actively hunt through the season (Quigg 1978:57) This is due to growing evidence that the bison herds tended to conglomerate on the plains over the winter and did not completely abandon the region as is often believed. These aggregated herds would not be split up into male and female herds as is often suggested in much of the literature.

CHAPTER 6

CANIDS AT THE SANDERSON SITE

6.1 Introduction

The recovery of canid remains from archeological sites is common on the Northern Plains and the Sanderson site is no exception. One of the most common problems in discussing these canid remains is whether or not they represent evidence of domestication. A number of analytical techniques were applied to the Sanderson site sample in order to discriminate between wild and domestic canids. The butchering pattern exhibited by the remains was also examined to determine the role these canids played in the subsistence strategies at the site.

The dog was the only domestic animal, with the exception of the turkey, kept by Native North Americans before European contact (Snyder 1991:359). The canids that lived with Native American groups filled the role of a beast of burden and occasionally were used as food (Crabtree & Campana 1987:102). Ethnographic reports provide evidence that large numbers of these animals were present in the camps and villages of many groups indicating that they were a year-round source of labour, protein and fat. In addition to these domestic animals were a number of wild species, including wolf and Swift fox. These represent canids that were likely attracted to the location of human subsistence activities such as butchering and processing. The last group of canids that may have been present would be the hybrids that occur between the various species, most

notably wolf and domestic dog, adding to the complexity and variation already supplied by the other groups.

6.2 Archaeological Evidence

The original location of canid domestication is difficult to determine. The widespread evidence of domestic dogs in Asia, Europe and North America has lead to the belief that domestication occurred in several localities around the world. It is likely that the Late Pleistocene and Early Holocene hunter-gathers at all these localities were using these canids for socially organized hunting, transportation and under certain conditions, food (Crabtree & Campana 1987:101).

The oldest substantiated finds of prehistoric domestic dogs in North America are those from Jaguar Cave, in the Beaverhead Mountains of Lemhi County, Idaho. Dates from the site indicate the age of the deposit ranges from about 9500 to 8400 BC The site was determined to be a hunting camp. The dogs had an unwolf-like appearance which was unusual in a dog so far south. This gap in morphology makes it likely that there is an undiscovered form of canid that remains between the domestic and feral canids (Olsen 1985:31). There are a number of other early records at the Horner site, Rodgers Shelter and the Koster site (Walker & Frison 1982:126). After these early finds the occurrence of canids in archaeological sites on the plains becomes more and more common up into the Late Prehistoric.

In order to assess canid remains in the archaeological record it is necessary to first separate the material into its different species. This has mainly been done using complete

skulls in order to note the differences in rostral length, tooth row size and skull length (Morey 1992:182). This is not always practical due to the fragmentary nature of archaeological material but being able to obtain a few measurements, especially on the teeth, can provide a basis for comparison with established bodies of data. Once obtained, it is necessary to determine the relative proportion of these measurements to one another as size alone is not an indicator of species. To understand why this is required it is necessary to look at biological relationship of domestic and wild canids.

6.3 Classification of Domestic Canids

The domestic dog shares the same number of chromosomes with the wolf, coyote, and jackal. This is perhaps the best evidence that these species are all in some way related. It is also possible for coyotes and wolves to cross and produce hybrids and both of these animals can mate with the domestic dog. The main inhibitor to common mating between the coyote and wolf is their size difference but more importantly, the social differences between the two species (Olsen 1985:12).

One of the biggest questions when canid material is encountered at an archaeological site is whether or not it is evidence of domesticated canids at the site. Domestic canids usually fall in the body size range between *Canis lupus* and *Canis latrans*. Although this might seem an easy initial method of classification it is important to realize that the most crucial difference between domestic and wild canids is not their relative size but the relative pattern of their skeletal development.

Osteological changes brought about by domestication are initially seen in the skulls, jaws, and dentitions of these tamed canids and include: the foreshortening of the muzzle, or rostrum(Olsen 1985, Morey 1992), the crowding of the tooth rows (Olsen 1985, Benecke 1987), different width to breadth ratios for the skull, the comparative overall reduction in the size of the teeth and the deepening of the mandibles midway along the horizontal ramus, with a more convex inferior margin than that found in similar sized wild wolves. These are only general rules, the amount of variation within wolf and domestic dog species can often cause an overlap between the two groups. Crowding of the tooth rows, for instance, is not always a good characteristic to differentiate wolves and domestic dogs as both can exhibit this dental characteristic (Hillson 1986:255) As well, the change in the skull proportions alone will not provide accurate determination of species. The skull will alter its form in order to accommodate brain size requirements at the different body sizes regardless of domestication (Morey 1992:197). The main difference noted among domestic dogs is in relative ratios between tooth size and head and body size which are disproportionate in comparison to wild canids. Rapid evolutionary changes in body size of domestic dogs has not been matched by the dental arcade (Morey 1992:198). This has resulted in smaller dogs with crowded teeth and larger dogs with relatively smaller teeth. Therefore identification can only be performed when it is proven that the difference between two specimens is not just the result of variation within a single species.

6.4 Classification of Wild Canids

Size, whether overall or of teeth, is the most obvious character separating wolves, coyotes and other wild canids. *Canis familiaris*, in size, spans the combined range of coyote and wolf and the combination of differences which distinguish particular specimens of dog from one another is even more variable (Lawrence & Bossert 1975:74)

The number of different breeds of dogs makes the osteological variation between domestic breeds obvious. Feral canids on the other hand are usually lumped into large canids in the form of wolves, medium canids in the form of coyotes, and small canids in the form of foxes. Despite this obvious categorization the degree of size variation within species is considerable. In a study of the morphological and ecological variation among gray wolves of Ontario, Kolensky and Standfield (1975) discovered that the variation in species was extremely complex and very dynamic.

The study compared Prairie wolf (*C.l. nubilis*) and a number of subspecies from Ontario including:

C.l. hudsonicus -Hudson and James Bays coastal regions
C.l. lycaon (Boreal type) -Northern and Central boreal forests
C.l. lycaon (Algonquin type) -deciduous/coniferous forest, a small wolf with some coyote-like characteristics
C.l lycaon (Tweed type) - southern limits of range of the Algonquin type

They took 27 measurements and 2 ratios from 105 adult skulls of the Algonquin type and 122 of the Boreal type. They found that there was a significant size difference between the larger northern wolves and the smaller southern ones even though their range overlapped. The Algonquin type was small and slender, with a narrow muzzle (Kolensky

& Standfield 1975:65). The Boreal type had a more massive skull while the Tweed type was smaller than the Algonquin type.

They also found that the massive skull and heavier weight of the larger boreal forest types had a closer affinity with the subspecies *C.l. nubilis* from the plains than the more southern subspecies of *C.l. lycaon* (Kolensky & Standfield 1975:71). It seems that despite an overlap in the range of the larger boreal types and smaller Algonquin types there is no conclusive evidence of interbreeding. Wolves taken out of this zone can usually be assigned to one type or the other without difficulty by a combination of morphological characteristics (Kolensky & Standfield 1975:71). The origins of the Tweed type, a relatively coyote-like wolf is obscure but there seems to be mounting evidence that it originated from hybridization between *C. latrans* and *C. lupus lycaon* (Kolensky & Standfield 1975:71).

The implications of such biological variation within a single species of canid are significant. The simple categorization of canids on size alone is not an assurance of correct species identification. The existence of regional variation within species requires careful consideration be taken before inter-site comparisons of canid material is undertaken. The sexual dimorphism within canid species and subspecies requires further careful analysis to ensure proper identification.

In respect to faunal analysis of archaeological assemblages such studies emphasize the necessity of using multivariate analysis and ratios of measurements to ensure proper identification of canids within assemblages when size variation exists. It

would be easy to misidentify two subspecies of wolves in an area of territorial overlap. The larger population would end up as wolves while a smaller subspecies at the same site could be improperly classified as domestics.

Fragmentary evidence makes this kind of detailed comparison difficult. The canid material from the Sanderson site has no complete skulls and only a few partially complete mandibles. Luckily, some of the skeletal landmarks remaining in the material have been used in studies differentiating domestic and wild canids. This will at least allow for a comparison with established bodies of information gathered from a wide range of animals and provide some indication of where the animals fit in to the range of variation.

6.5 Analysis

There have been a variety of methods used in the past to speciate the skulls of different canids. Most of these depend on multivariate analysis using multiple measures on complete skulls. The lack of good cranial material at the Sanderson site limited the usefulness of these approaches but the existence of several fragmentary mandibles allowed for a number of other forms of analysis to be attempted. These analyses often depended on univariate and mulitivariate techniques where a small number of measurements would yield results.

6.5.1 Cranium and mandible

Univariate methods of analysis

There is one fragmentary skull (71076) from occupation one at the Sanderson site (Figure 6.1). The skull is composed of an occipital, right and left temporals, basisphenoid, right frontal fragment, and a right maxilla with P^4, M^1, M^2. Although there are several univariate methods of analysis designed to classify canid species using the cranium the Sanderson site material was too fragmented for anything but ambiguous results.

Figure 6.1 Fragmented Canis. Sp cranium (71076), Sanderson site.

Although the skull is usually the focus of much of the research on the differences between wild and domestic canids, there have been a number of studies done that use the information from the mandible and dentition. The Sanderson site had far more mandibular material making these studies useful in the differentiating species.

In a study of near eastern domesticated dogs Dayan (1994) used 5 measurements which included:

1. Length of the lower carnassial, measured at the cingulum (M_1L).
2. Length of the premolar row P_1-P_4, measured along the alveoli (P_{1-4}).
3. Height of the mandible behind M_1, measured at right angles to the basal border (MH).
4. Length of the upper carnassial, measured at the cingulum (M^1L).
5. Length of the upper cheek tooth row (P^1-M^2)

The measurements were then compared to a recent population of Israeli wolves and a t-test was performed to see if the differences in the measurements were significant from the population variance in the wolf population. Dayan (1994:639) found significance and a general trend over time in the domestic populations. The length of both the upper and lower carnassial decreased and the length of the tooth row was also reduced.

To test if the Sanderson site canid material followed the same trend the sample was compared to the Near Eastern wolf material and wolves from the University of Saskatchewan comparative collection to see if they varied significantly on any of these

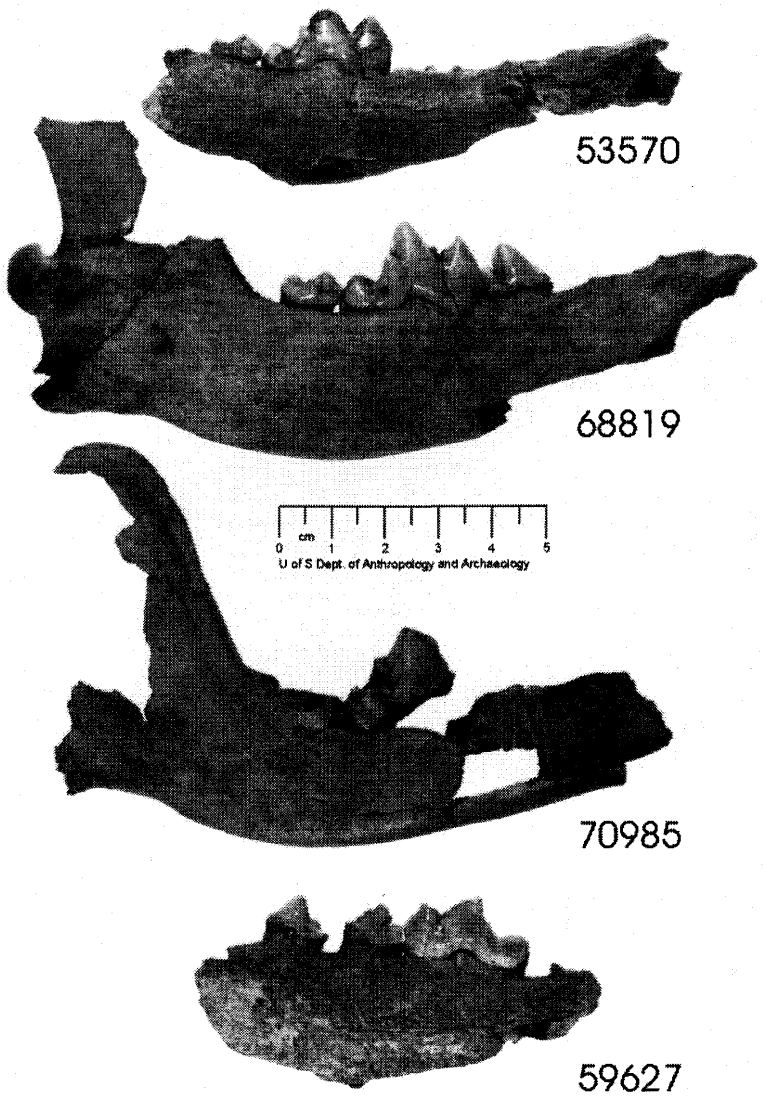
measurements (Table 6.1). The Israeli population was only included for the sake of comparison. Its use as a comparative sample for North American wolves is limited.

Table 6.1 Sample statistics (N=sample size, s.d.= Standard deviation,) for the Israeli wolf population (*Canis lupus pallipes*) (data from Dayan 1994:636), *Canis lupus* (data from University of Saskatchewan comparative collection), and *Canis familiaris* (data from University of Saskatchewan comparative collection).

	M_1L	MH	P^4Le
Species			
Canis lupus pallipes			
N	36	-	34
Mean	24.41	-	22.42
s.d.	1.13	-	1.1
Canis lupus			
N	4	4	4
Mean	28.76	30.26	25.19
s.d.	1.68	1.55	0.48
Canis familiaris	1	1	1
	22.5	26.8	20.23

The University of Saskatchewan material was analyzed and then subjected to a single sample t-test using Arcus Quickstat software to see if the variance in that population matched the Israeli population and to see if any relationship existed with the cranium (Figure 6.1) and mandibles (Figure 6.2) of the Sanderson site material (Table 6.2). There is only one domestic dog in the collection so population variance was not possible on a sample of one, it was included as a comparative specimen but its statistical value is limited. This analysis yielded a number of interesting results. Two mandibles (53570 & 59627) were significantly different from the wolf population. These mandibles halves

Figure 6.2. Canis sp. mandibles (68819, 70985, 53570, 59627, 71069), Sanderson site.



were not found together but are right and left halves so they may represent the same individual despite a difference in lower carnassial length. The maxilla (71069) from the fragmentary cranium (71076) also had a carnassial measurement that was significantly different from the wolf sample. The other two mandibles (68819 & 70985) were not significantly different from the wolf sample in two separate measurements.

Table 6.2 Sanderson site remains with catalogue number, description analytical results. *Canis familiaris* from University of Saskatchewan comparative collection. Measurements that differ significantly (P<0.05) from the mean of the University of Saskatchewan sample of recent wolves are denoted by an asterix.

Catalogue number	Description	Occupation	M1L	MH	P4Le
68819	Mandible	1	27.05	28.8	-
70985	Mandible	1	27.05	28.35	-
53570	Mandible	2	24.9*	-	-
59627	Mandible	2	23.8*	-	-
71069	Maxilla	1	-	-	22.95*
Canis familiaris			22.5*	26.8*	20.23*

In order to interpret these results it is necessary to make a number of points explicit. If the Israeli wolves described by Dayan (1994) were compared to the University of Saskatchewan wolf sample there would be a significant difference in the tooth size. The Israeli wolves would have appeared smaller and that would have fit well into Dayan's criterion used to define domestic dogs. The two mandibles and the skull from the Sanderson site that were significantly different from the North American population of wolves were not significantly different from the population of Israeli wolves and would never have been noticed as a candidate for domestication.

Therefore the canid material that appeared significantly different at the Sanderson site must be viewed with a number of considerations. It is necessary to be aware of the wild canid population that is being compared with the archaeological material. This study and the one by Kolensky and Standfield (1975) make it abundantly clear that there

is size variation within a single species of canids. It is important to establish the existence and geographical range of prehistoric populations before any positive conclusions can be reached. Luckily the sample at the University of Saskatchewan had a very low variance within the sample indicating that they were likely all from a similar subspecies. Sexual dimorphism aside they represent a good sample population of large North American wolves. This suggests that the significant size difference between this population and the Sanderson site material is likely due to the existence of *Canis familiaris* at the site. Until the existence of a wild population of wolves that represents a smaller subspecies of the larger *Canis lupus nubilis* is found to exist on the northern Plains this canid material can be considered to be from a domestic dog population.

Bivariate methods of analysis

Valkenburgh and Koepfli (1993) designed one of the most detailed multivariate analysis methods of the canid cranium and mandible. The method was developed in order to separate canids into one group that hunted prey larger than themselves, and another group which included canids that hunted small prey and/ or were omnivorous (Valkenburgh and Koepfli 1993:16). The groups that hunted prey larger than themselves could be separated out on the basis of a number of characteristics that typified that group, including relatively reduced grinding areas of their dentition, larger canines and incisors, broader snouts, wider occiputs, larger second moments of area of the dentary relative to its length and increased advantage of the major jaw closing muscles. This translates into larger bite forces at the canines and an efficient slicing surface on the carnassials which is

consistent with an adaptations towards killing and consuming large ungulates (Valkenburgh and Koepfli 1993:33).

Domestic dogs on the Northern Plains are usually described in the ethnographic literature not as active hunters but as scavengers that depended on human refuse. If they had followed this pattern for several thousands of years it would seem likely that they would fall outside of the group that depended on hunting large ungulates, including the gray wolf, and more into the omnivorous canids such as coyotes and foxes. Their carnassials would likely have increased molar area for grinding and their jaws would be more adapted for chewing than for large bite forces. Once again the fragmentary evidence limited the number of measurements that could be applied from this study. The measurement that could be used for most of the mandibles and the comparative collection was the relative blade length (RBL). This is a measure of the lower first molar, the carnassial, as a ratio of trigonid length to the total anteroposterior length of M_1.
The University of Saskatchewan *Canis lupus* material was analyzed and then subjected to a single sample t-test using Arcus Quickstat software to see if the variance in the RBL ratio of that population had any relationship with the Sanderson site canid material (Table 6.3). In the course of the analysis both mandible 53570 and 59627 showed a significant difference from *Canis lupus* for this particular ratio. This is then in agreement with the previous analysis that these two mandibles represent a species other than wolf. This analysis reveals a difference in the shape of the carnassial as well as the size. The domestic dog from the collection exhibited the same significant difference. The trigonid

Table 6.3 Sanderson site remains with catalogue number, description and RBL. *Canis lupus, Canis familiaris* from University of Saskatchewan comparative collection. Other canid measurements from Van Valkenbutgh & Koepfli (1993). Measurements that differ significantly (P<0.05) from the mean of the University of Saskatchewan sample of recent wolves are denoted by an asterix.

	RBL		RBL
U of S Collection		**Sanderson site**	
Species			
Canis lupus		68819	0.64
N	4	70985	0.66
Mean	0.635	53570	0.72*
s.d.	0.02	59627	0.69*
		71069	-
Canis familiaris	0.69*		
Van Valkenburgh & Koepfli (1993)			
Canis lupus			
N	10		
Mean	0.646		
Canis latrans			
N	10		
Mean	0.643		
Alpex lagopus			
N	10		
Mean	0.622		
Vulpes ruppelli			
N	10		
Mean	0.677		

of the lower carnassial appears to be larger in relation to the overall size of the tooth.

This represents a larger shearing surface for the tooth in domestic dogs versus wolves.

Valkenburgh and Koepfli (1993) did not include domestic canids in their original study as they were looking at how the preferred prey species of different canids changed the morphology of the dentition and jaws under condition of natural selection. They successfully proved that the canids that attacked large ungulates did indeed have a larger carnassial shearing surface as well as a more powerful biting action and larger canines. The fact that the domestic dog from the comparative collection and the domestic canids from the Sanderson site exceed this measure seems more likely to be the effects of the unnatural forces of domestication rather than evolutionary forces. Although domestic dogs on the plains would have continued their role as hunting dogs in the nomadic hunter gather tribes of the area, there is no reason for such a dramatic change in the size of their carnassials. A more likely explanation lies in the overall trend towards smaller teeth in domestic dogs. As the teeth became smaller the cusps did not necessarily keep pace with the rapid changes. It seems likely that the domestic dogs kept the same amount of shearing edge as the overall size of the tooth decreased. This would have resulted in the high RBL ratios that came from the sample. If this ratio holds true it may be a useful way of evaluating fragmentary canid remains in archaeological sites on the Northern Plains

Analysis was also undertaken using the methods outlined by Lawrence (1968). These measurements were designed to provide ratios expressing mandibular proportions that would separate domestic from wild canids (Lawrence 1968:43). There were four separate ratios but due to their fragmentary nature not all of them could be applied to the materials from the Sanderson site. The same ratios were used by Walker (1995), adding

to the comparative sample. Lawrence (1968:43) believed that ratio 2 was the most distinctive indicator, while Walker (1995:64) thought ratio 4 was the only worthwhile measurement for identifying modern characteristics. Table 6.4 shows the Sanderson site material compared to the data of both Lawrence(1968) and Walker(1995).

The two specimens 70985 and 68819 both fall well within the range of *Canis lupus* in both ratio I and ratio II. Both of these were recognized as wild canids in the early analysis so this fits well with conclusions from other analytical methods. The other two specimens 53570 and 59627 are more problematic as they do not both fall easily in the *Canis familiaris* classification given to them by the other analyses. Specimen 53570 has

Table 6.4 Ratios expressing mandibular proportions in wolves, coyotes, European domestic dogs, North American prehistoric domestic dogs (Walker 1995:66) and the Sanderson site materials.

	RATIO I Breadth of jaw below M1: Crown length M1	RATIO II Breadth anterior base ascending ramus: crown length M1	RATIO III Breadth anterior base ascending ramus: height ascending ramus	RATIO IV Breadth symphysial surface: alveolar length i1 to posterior p2
Canis lupus (N=34)	39.4-56.0	34.5-49.8	14.3-19.7	25.5-31.3
Canis latrans (N=100)	37.7-50.2	30.6-44.1	13.3-18.9	22.8-29.3
Canis familiaris (N=15)	31.8-63.6	24.6-44.9	11.6-19.2	17.4-33.1
Birch Creek *Canis familiaris*	53.9-58.8	48.5-56.2	18.9-26.2	35.0-36.2
Jaguar Cave	55.6	51	-	36.5
Cactus Flower	59.4	53.7	20.4	-
Hendrickson III	54.9	49.8	-	-
Seminoe *Canis familiaris*	49.0-52.1	41.5-44.4	17.3-18.4	33.0-33.9
Vore hybrids (N=5)	43.1-53.1	38.4-49.2	17.5-19.0	23.3-33.2
Seminoe hybrids (N=5)	47.7-53.2	39.0-45.4	18.1-20.4	31.6-37.9
Sanderson site				
70985	47.6	40.8	-	-
68819	49.2	38.1	-	-
53570	52.3	-	-	-
59627	59.2	-	-	-

a ratio I that still falls into the range of *Canis lupus*. Specimen 59627 on the other hand has a ratio I that is above the range of *Canis lupus* and into the range of some of the other domestic dogs used in the comparison. Obviously these measures could not be used as the sole determinant of species affiliation. Both Lawrence (1968) and Walker (1995) do not recognize these particular ratios as the most indicative of species differentiation and therefore this information can be used as a general guide but it does not provide the best information from fragmentary faunal remains.

The use of bivariate plots has also proven useful in the analysis of canid mandibles. The methods of Bokonyi (1975) for bivariate plots of mandibular measurements were used successfully to demonstrate differences between wild and domestic canids in Europe. Walker & Frison (1982) used the same methods to successfully analyze North American canid populations. The same measurements were taken from the Sanderson site mandibles (Table 6.5) and plotted on Figure 6.3. The wolf mandibles from the University of Saskatchewan comparative collection were also plotted in order to show the affiliations of the archaeological material with a modern sample.

The data plot of figure 6.3 indicates that mandibles 68819 and 70985 from occupation one are still consistently within the range of *Canis lupus*. The other mandible from occupation one, 50576, was plotted as an intercept at 23.8, this places the mandible within the *Canis familiaris* area of the figure. Lacking the second measurement limits the validity of this classification but regardless of the second measure the mandible would either fall into the domestic dog category or become an outrider, there is no way for it to

Figure 6.3 Bivariate plot for Length of lower M_1 to Alveolar length of lower M_1 to M_3, dashed lines indicate mandibles from which only one measurement was possible.

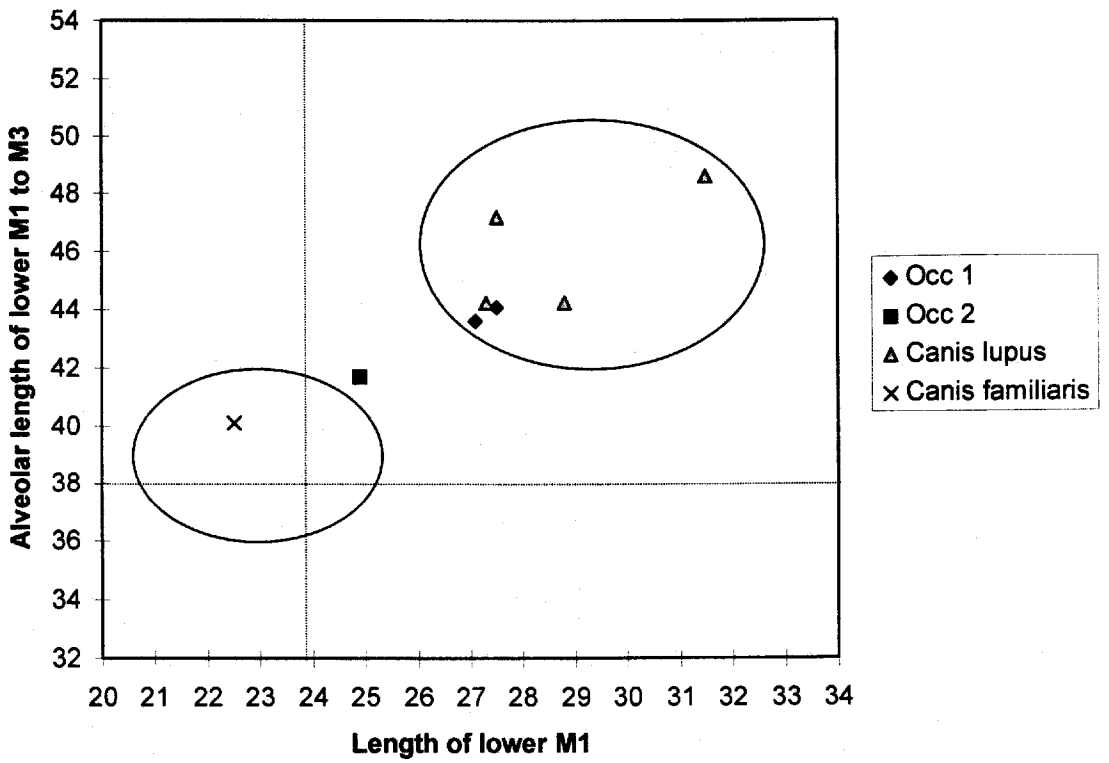


Table 6.5 Data for bivariate plot

Specimen	Alveolar length of lower P1 to P4	Length of lower M1	Alveolar Length of lower M1 to M3
Occ1			
68819	-	27.5	44.1
70985	-	27.1	43.6
50576	-	-	37.9
Occ2			
53570	-	24.9	41.7
59627	-	23.8	-
Canis lupus			
M02-03-04	-	31.5	48.6
M02-03-03	-	27.5	47.2
M02-03-29	-	28.8	44.25
M02-03-02	-	27.3	44.25
Canis familiaris	-	22.5	40.1

be placed in with the wild canids. Only mandible 53579 could be completely plotted for occupation two. This mandible again exhibits a plot close to the domestic dog but not completely within the plot area. This result and previous results may indicate that the individual is a hybrid, exhibiting characteristics from both wild and domestic canids. The other mandible from occupation two, 59627, was also flawed by a single measurement. The intercept plotted again passed through the range of domestic dogs and could not have been classified as a wolf no matter what the second measure. This is consistent with earlier classifications of the mandible as a domestic dog.

6.6 Summary of Analysis

There are 5 mandibles and one skull that allowed any form of analysis at the Sanderson site. The results of this analysis are summarized in Table 6.6. The single cranium was problematic due to the limited number of measurements and therefore analytical methods that could be applied. The one measure of carnassial size did provide

Table 6.6 Summary of Canid species identification

Specimen	Side	Species	Comments
Cranium			
Occ 1			
71076	Axial	likely *Canis familiaris*	Based on a single univariate analysis
Mandible			
Occ 1			
68819	Left	*Canis lupus*	
70985	Right	*Canis lupus*	
50576	Right	likely *Canis familiaris*	Extrapolated from a single measurement
Occ2			
53570	Left	*Canis familiaris* or hybrid	Some overlap in analysis results
59627	Right	*Canis familiaris*	

significant differences from wild canids but it is best to be cautious. The mandibles were a bit more successful. Mandibles 68819 and 70985 are definitely of the species *Canis lupus*. They remained within that population for every type of analysis performed and showed no ambiguity. They may be two halves of the same jaw despite minor differences in some of the measurements from the two jaws. The other mandible from occupation one, 50576, was limited in types of analysis which could be applied due to a complete lack of teeth in the jaw. The size and some of the measurements from the jaw were consistent with *Canis familiaris*, but without significant results as proof, its classification is tenuous. The two mandibles from occupation two both had inclinations towards domestic species. Mandible 53570 showed a consistent tendency towards a classification as *Canis familiaris* but some of the analytical methods were ambiguous or put the specimen at the edges of that category. It is possible that it could be a very large domestic dog or a hybrid between wild and domestic animals that has a mix of both characteristics. Mandible 59627 consistently came up as different from wild populations. This is conclusive proof that this particular specimen is a domestic canid.

6.7 Immature Canids

There were a number of immature remains found at the Sanderson site (Figure 6.4). The aging of the mandibles was assisted by a radiograph that shows the position of all the unerupted teeth in the jaw. Figure 6.5 shows a laterally oriented image of the mandibles. In both of the mandibles the M_1-M_3 are forming in the jaw but have not fully erupted. Mandible 49123 had a full profile of all the mandibular dentition with a good

Figure 6.4 Immature Canis sp. mandibles (52679, 49123), Sanderson site.

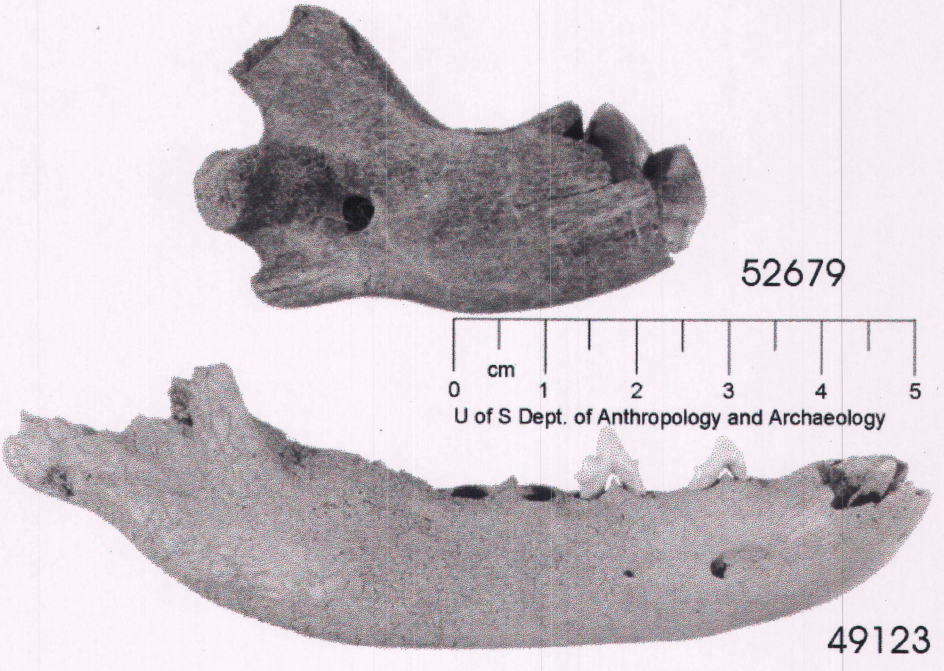
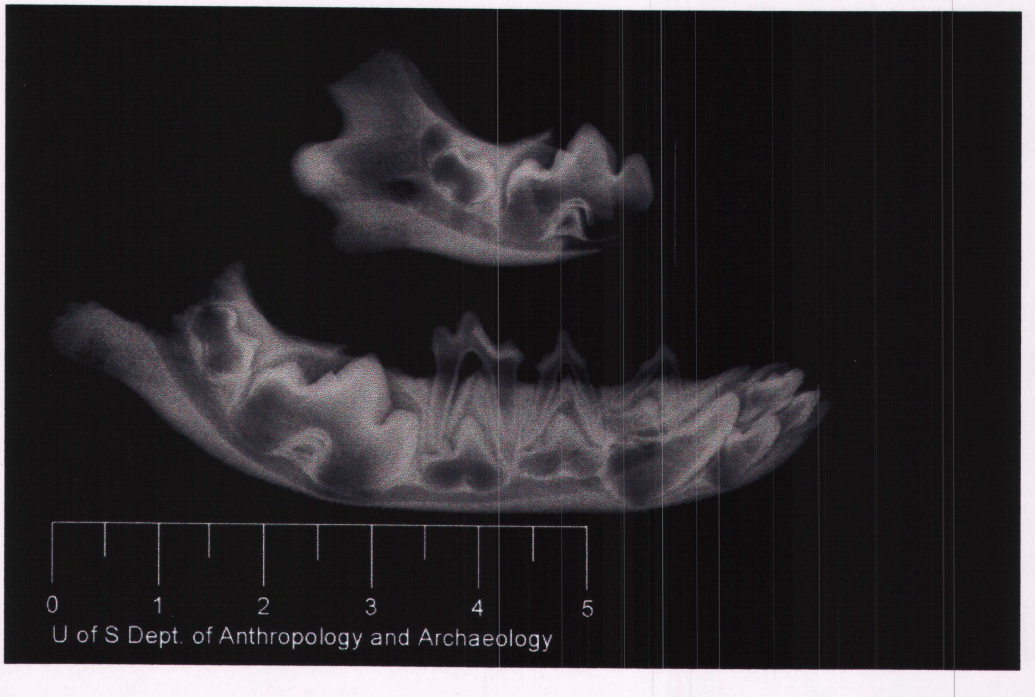


Figure 6.5 Radiograph of Immature Canis sp. mandibles (52679, 49123).



view of P_1-P_4 and M_1-M_3 still forming in the jaw. Based on this and an eruption schedule as outlined in Hillson (1986:217) and Sisson and Grossman (1963:503) the immature canid was at least 5 weeks old but no older than 3 months. The identical state of the unerupted molars in mandibles 52679 and 49123 indicates that if they didn't come from the same animal then they were at least litter mates at the same stage of development. There is no seasonality indicated by these mandibles as it is impossible to differentiate species based on an immature mandible. Wolves and dogs share a common gestation period of 63.0 ± 5 days but while wolves have a breeding period that begins at the end of February, domestic dogs do not have an annual estrous cycle and can conceive at any point in the year (Hillis & Mallory 1996:2213). This makes any conclusions about the exact season of birth for these canids unlikely.

The use of puppies as a food source has been documented at other sites (White 1955:172) and the burned condition of the Sanderson site immature mandibles indicates that they were likely being cooked as well. Ethnographic information indicates that it was common to kill off at least some of every litter in order that the puppies not weaken the mother (Wilson 1924:200). The age of the puppies from the Sanderson site puts them beyond the initial cull but there is also some indication that as the puppies grew they would continue to be culled if they showed any weakness or aggressive tendencies (Wilson 1924:200).

6.8 Conclusions

There are a few other methods of species identification for canids used in Plains assemblages such as Walker (1975) and Walker and Frison (1982) but none contained techniques that produced significant differences or used the landmarks that remained in the fragmented material at the Sanderson site. Although a multivariate analysis of the canid remains would have provided more clues about their relative closeness to one another it was only possible to separate them into species groups. Considering the lack of other analyses on fragmentary remains in the literature this study at least shows the possibilities that remain even though the material is not in prime condition

CHAPTER 7

TAPHONOMY OF THE SANDERSON SITE FAUNAL ASSEMBLAGE

7.1 Introduction

It is necessary to distinguish between natural and cultural modification of a bone bed before any conclusions can be reached about the meaning of a faunal assemblage. The taphonomy of the Sanderson site is then an analysis of the post-mortem processes that acted upon the faunal remains. Taphonomy is an area of research that "defines, describes, and systematizes the nature and effects of processes that act on organic remains after death" (Gifford 1981:366).

In order to evaluate the combination of cultural and natural factors that contributed to the Sanderson site formation a number of analytical methods were applied to the faunal assemblage. These were designed to evaluate the completeness of the bone and the attrition profile due to different kinds of butchery and density mediated survival of the bone. The assemblage was also covered by more descriptive methods that presented such natural forces as weathering, abrasion and polish, carnivore attrition, digestive corrosion, and root erosion. These same descriptive methods were used to describe cultural forces such as cutmarks and excavation or preparation damage.

7.2 Defining Bone Portions

The coding of the Sanderson site presented a challenge due to its high degree of fragmentation. In order to deal with this problem, the skeletal elements of the bison were recorded in terms of discrete anatomical features of the bones. The most abundant portion of an element is used to determine the MNE for that element and its overall frequency in the assemblage is used to calculate the MAU. The portions used are an

expansion of the categories defined by Morlan (1994b). The use of this system allows a much more accurate picture of the assemblage than would be allowed by the traditional method of counting complete, proximal and distal bone elements. Morlan (1994b) made this point when he examined the problems with the use of discrete bone portions to analyze bone elements. The use of proximal and distal portions of a long bone alone does not provide an adequate picture of the assemblage. Table 7.1 indicates how much difference there is in a highly processed assemblage such as this.

The complete proximal and distal elements are defined as articular ends of a long bone that possess a complete articular surfaces and at least some of the accompanying

Table 7.1. Comparison of %MAU as calculated by element landmark, complete portion and portion landmark.

Occupation one	%MAU	Occupation two	%MAU
Humerus(landmark)	53.3	Humerus(landmark)	62.5
Prox. Humerus(complete)	0.0	Prox. Humerus(complete)	6.3
Prox. Humerus(landmark)	6.7	Prox. Humerus(landmark)	12.5
Dist. Humerus(complete)	33.3	Dist. Humerus(complete)	18.8
Dist. Humerus(landmark)	53.3	Dist. Humerus(landmark)	62.5
Radius(landmark)	86.7	Radius(landmark)	37.5
Prox. Radius(complete)	13.3	Prox. Radius(complete)	25.0
Prox. Radius(landmark)	86.7	Prox. Radius(landmark)	37.5
Distal Radius(complete)	6.7	Distal Radius(complete)	0.0
Distal Radius(landmark)	60.0	Distal Radius(landmark)	12.5
Femur(landmark)	73.3	Femur(landmark)	56.3
Prox. femur(complete)	0.0	Prox. femur(complete)	6.3
Prox. femur(landmark)	73.3	Prox. femur(landmark)	6.3
Dist. Femur(complete)	0.0	Dist. Femur(complete)	0.0
Dist. Femur(landmark)	26.7	Dist. Femur(landmark)	6.3
Tibia(landmark)	93.3	Tibia(landmark)	93.8
Prox. Tibia(complete)	0.0	Prox. Tibia(complete)	0.0
Prox. Tibia(landmark)	26.7	Prox. Tibia(landmark)	0.0
Dist. Tibia(complete)	26.7	Dist. Tibia(complete)	50.0
Dist. Tibia(landmark)	93.3	Dist. Tibia(landmark)	93.8

bone shaft. The %MAU of the articular end based on landmark alone is a measure of the most numerous discrete anatomical landmark counted from the articular end. It is obvious that simply recording the complete proximal and distal ends of the bone results in an under representation of that bone portion.

Throughout the faunal analysis it is necessary to discuss the bone portions in relation to other faunal assemblages and analytical methods. There are a number of methods that rely on the comparison of proximal and distal ends of long bones. In such situations the numbers from the Sanderson site will be explicitly stated to be from complete portions of elements or counts based on landmarks alone.

7.3 Completeness

One of the limitations of traditional MAU and MNE counts of faunal assemblages is their measurement of skeletal element abundance in a faunal assemblage and not the degree of fragmentation in that assemblage. Using an expansion of the bone element portions as outlined by Morlan (1994b) the Sanderson site was counted by discrete bone portions and the minimum number of elements calculated by the most numerous of these portions. Documenting the assemblage this way allowed the calculation of percent completeness as well. The calculations used were outlined by Morlan (1994b:805) using the following formula:

$$\%CN = \left(\frac{((PP)(NISP))}{PD} \right) x100$$

% CN = Percent Completeness
PP = Total number of Portions Preserved (sum of MNE values)
NISP = Number of identified specimens
PD = Number of Portions Defined

The results in Table 7.2 compare the percent completeness of the Sanderson site assemblage with the Harder and Sjovold sites. Table 1 in Appendix III is a complete count of all the portions used to calculate these numbers. It is obvious that the Sanderson site assemblage has been heavily processed, exceeding the degree shown by the percent completeness of both the comparative sites. The Harder site is most like the Sanderson site in the type of fragmentation that occurred at the site but even then, there are noticeable differences in the scapula, radius and innominate.

Table 7.2 Comparison of % Completeness between the Sanderson site occupations and the Harder and Sjovold sites (Data from Morlan 1994b:805)

Element	% Completeness			
	Sanderson Occ1	Sanderson Occ2	Harder	Sjovold
Mandible	2.2	1.5	8.2	9.7
Scapula	1.9	1.3	21.4	24.0
Humerus	9.6	8.9	15.5	16.4
Radius	7.5	3.5	19.7	24.3
Ulna	9.9	11.5	27.3	28.1
Metacarpal	18.9	7.4	33.0	36.0
Innominate	10.9	4.2	19.6	22.3
Femur	9.1	10.2	11.7	20.0
Tibia	4.7	8.2	24.6	20.0
Calcaneous	18.7	37.7	49.6	89.0
Metatarsal	7.2	12.4	33.5	32.4

The differences are also obvious when the long bones alone are compared. In both the Harder and Sjovold assemblages the percent completeness of the limb elements increases distally. The metacarpals and metatarsals exhibit the highest completeness for any limb element. In the Sanderson site assemblage only the forelimb elements of occupation one show this pattern. The hindlimb elements of occupation one and the fore and hindlimb elements of occupation two both show a lack of this pattern.

Figure 7.1 is a comparison between the percent completeness of Sanderson site occupation one and occupation two. The number of elements has been expanded to include carpals, tarsals, vertebrae, and phalanges. The result of this expanded selection shows that the carpals of the forelimb tend to be the most complete of any of the skeletal elements within the assemblage. The phalanges are the next most likely element to be complete. The tarsals drop in percent completeness and are then followed by the extremely fragmented long bones.

Another method of calculating the level of completeness was outlined by Todd and Rapson (1988) but the method relies on an assemblage that has at least some complete elements within the assemblage. When the methods is applied to heavily processed sites, completeness is always zero. The Late Prehistoric Period sites Bugas-Holding site represents a long term winter occupation. Like the Sanderson site, it exhibits a high degree of processing so using an analytical method that looks at the number of complete elements within the site will provide no information.

In such a situation it is more useful to look at any patterns of differential destruction of articular ends as a measure of long bone fragmentation. The percent difference is a method to identify skeletal elements which have differential destruction of one articular end. It is only a method for the comparison of patterns of fragmentation between sites and does not indicate the processes responsible for the differences (Todd & Rapson 1988:313). Table 7.3 indicates that the percent difference of the Sanderson site exceeds all other sites used for comparison. Only the values for complete articular ends were used in the comparison. Even Bugas-Holding, a Late Prehistoric site with considerable processing, does not have as obvious differential destruction as the

Figure 7.1 Comparison of %Completeness in occupation one and occupation two.

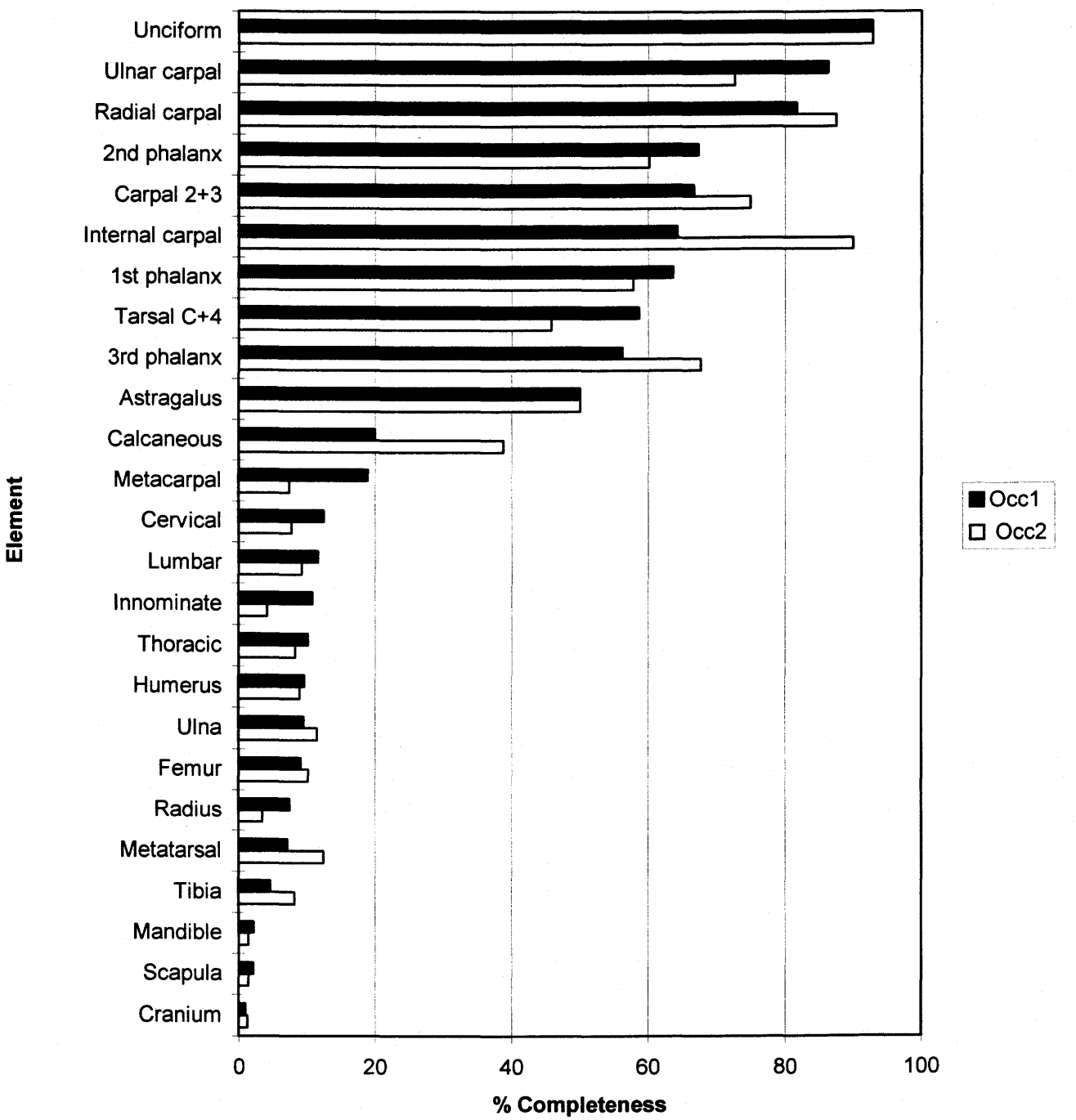


Table 7.3. Percent difference for the Sanderson site, Paleoindian, Late Prehistoric Period bison bone beds and wolf kills (data from Todd and Rapson 1988).

Element	Sanderson Occ1	Sanderson Occ2	Bugas-Holding	Jones-Miller	Horner II	Casper	Olsen-Chubbock	Lamb Spring	Wolf kills
Humerus	100.0	100.0	83.3	55.3	41.0	40.7	1.4	54.6	60.0
Radius	33.3	100.0	28.0	0.8	22.6	1.5	5.5	16.7	23.1
Metacarpal	60.0	100.0	50.0	3.0	1.8	0.6	-	0.0	0.0
Femur	-	100.0	33.33	13.3	12.8	4.0	3.6	0.0	39.1
Tibia	100.0	100.0	58.3	21.6	17.3	12.5	2.0	17.2	37.5
Metatarsal	-	100.0	25.0	0.7	1.2	0.9	-	13.3	30.8

Sanderson site. It is apparent that the Sanderson site represents an extreme of fragmentation, even with other Late Prehistoric sites.

7.4 Skeletal Part Frequencies

Minimal animal units (MAU) are the measure traditionally used in the reconstruction of an archaeological assemblage. The MAU indicates the most abundant elements in an assemblage and those which are under represented due to a range of taphonomic factors including cultural butchering and transport, scavenging, density-mediated attrition, or a combination of these factors. The Sanderson site represents a difficult situation as most assemblages are evaluated by the number of complete elements found in the assemblage or at the very least the number of complete proximal and distal ends. The Sanderson site's element MAU was evaluated by the highest MAU represented by the landmarks on the element. This provides a count for a skeletal element even if it only exists in a fragmented form. The element is still in the assemblage but it has undergone some alteration. This may well include elements which would otherwise not be included in conventional MAU counts based on whole bone portions. A complete list of MAU by anatomical landmark is presented in Appendix III, Table 1. The MAU counts

at the Sanderson site will be used to measure %MAU. The %MAU of an element is a measure of the difference between the expected number of elements versus the number of elements found in the assemblage and a summary is presented in table 7.4. This is based on the highest MAUs summed from the landmarks counts of the individual bones.

Bison

In occupation one the highest %MAU was 100% in the cranium and the fused central and fourth tarsal and the lowest was the caudal vertebrae at 2%. The cranial count was based on the first molar. In occupation two the highest %MAU was 100% for the lateral malleolus with a low of 1.4% for the rib head. The sternum did not have any representation in either of the occupations and had a resulting %MAU of zero.

Both occupations exhibit similar levels of representation. The better represented elements include the cranium, mandible, carpals, tarsals, and phalanges. The best representation for the long bones in both levels is the tibia. Vertebral elements do not appear well represented in either of the levels.

Table 7.4 Ranked % MAU for Sanderson site *Bison bison* elements

Occupation one	% MAU	Occupation two	% MAU
Cranium	100.0	Lateral malleolus	100.0
Tarsal C+4	100.0	Tibia	93.8
Mandible	93.3	Astragalus	87.5
Tibia	93.3	Cranium	68.8
Tarsal 2+3	86.7	Tarsal 2+3	68.8
Radius	86.7	Humerus	62.5
Internal carpal	73.3	Calcaneous	62.5
Femur	73.3	2nd phalanx	60.0
Lateral malleolus	73.3	Internal carpal	56.3
Radial carpal	66.7	Femur	56.3
Ulnar carpal	66.7	Carpal 2+3	56.3
Carpal 2+3	60.0	Metatarsal	56.3
2nd phalanx	57.3	Ulnar carpal	50.0
Humerus	53.3	Dist. Tibia	50.0
Unciform	46.7	Superior-medial	45.0
Superior-lateral	43.3	Mandible	43.8
Ulna	40.0	Radial carpal	43.8

Table 7.4 con't

Dist. Ulna	40.0	Unciform	43.8
Metacarpal	40.0	Superior-lateral	42.5
Astragalus	40.0	Radius	37.5
Superior-medial	40.0	Patella	37.5
1st phalanx	34.7	1st phalanx	32.5
Dist. Humerus	33.3	Tarsal C+4	31.3
Calcaneous	33.3	Ulna	31.3
Axis	26.7	Metacarpal	31.3
Accessory carpal	26.7	Innominate	31.3
Dist. metacarpal	26.7	Inferior	26.3
Innominate	26.7	Sacral	25.0
Dist. Tibia	26.7	Dist. Ulna	25.0
Metatarsal	26.7	Axis	25.0
Rib head	22.1	Accessory carpal	25.0
Scapula	20.0	Prox. Radius	25.0
Patella	20.0	3rd phalanx	22.5
Inferior	20.0	Dist. Humerus	18.8
Lumbar	18.9	Hyoid	18.8
3rd phalanx	14.7	Scapula	12.5
Hyoid	13.3	Atlas	12.5
Atlas	13.3	Prox. Metatarsal	12.5
Distal Radius	13.3	Lumbar	7.3
Tarsal 1	13.3	Cervical	7.1
Sacral	13.3	Dist. metacarpal	6.3
Cervical	9.5	Tarsal 1	6.3
Thoracic	9.2	2nd metatarsal	6.3
Prox. Radius	6.7	Prox. Humerus	6.3
Prox. metacarpal	6.7	Prox. femur	6.3
2nd metatarsal	6.7	Thoracic	3.9
Caudal	2.0	Caudal	2.5
Sternum	0.0	Rib head	1.4

Canids

None of the canid material provided a very large sample to determine patterns. No conclusions could be reached about the small *Canis sp.* and the medium *Canis sp.* due to a small sample. Table 7.5 and 7.6 present the ranked %MAU of *Vulpes velox* and large *Canis sp.* respectively.

The information from the %MAU of *Vulpes velox* is still difficult to discern due to its small size. In both occupation one and two there is a mix of axial and appendicular

Table 7.5 Ranked % MAU for Sanderson site *Vulpes velox* elements

Occupation one	%MAU	Occupation two	%MAU
Mandible	100.0	Humerus	100.0
Humerus	75.0	Mandible	66.0
Scapula	25.0	Cranium	33.0
Femur	25.0	Tibia	33.0
Second metatarsal	25.0	Vertebrae	0.0
Vertebrae	0.0	Radius	0.0

Table 7.6 Ranked % MAU for Sanderson site large *Canis sp* elements

Occupation one	%MAU	Occupation two	%MAU
Atlas	100	Sacral	100
Radius	50	Ulna	100
Innominate	50	Second metacarpal	100
Second phalanx	50	Third metatarsal	100
First phalanx	50	Lumbar	100
Ulnar carpal	50	Thoracic	100
Axis	50	Axis	100
Cervical	50	Cervical	100
Third metacarpal	50	Third metacarpal	100
Fourth metacarpal	50	Fourth metacarpal	100
Thoracic	35	Mandible	100
Lumbar	30	Fourth carpal	50
Hyoid	25	Central tarsal	50
Scapula	25	Second metatarsal	50
First carpal	25	Radial carpal	50
First tarsal	25	Fifth metacarpal	50
Fourth metatarsal	25	Third tarsal	50
Indt. medapodial	25	Fourth tarsal	50
Radial carpal	25	Ulnar carpal	50
Fifth metacarpal	25	Indt. medapodial	30
Third tarsal	25	First phalanx	30
Fourth tarsal	25	Second phalanx	20
Second metacarpal	25	Third phalanx	6
Third metatarsal	25	Caudal	6
Caudal	15	Sternum	0
Sesamoid	10	Humerus	0
		Accessory carpal	0

elements. There does not seem to be any dominant pattern although there is a distinctive lack of vertebral and distal appendicular elements. The small size of the sample from the large *Canis sp.* sample allows a few patterns to be observed. In occupation one and two the predominant elements were skull, vertebral and distal appendicular. This fits well with White's (1955:172-73) description of the butchering patterns for canids at the Buffalo Pasture site and the Rock Village site. At these sites the head was removed by severing the neck through the atlas. The meat was then stripped off the backbone and the vertebrae discarded. In both the forelimb and hindlimb the limb was severed above the carpals and tarsals and the limb removed from the body at the proximal humerii and femur.

7.5 Utility and Density

The fragmentation in a faunal assemblage is usually attributed to two factors, human utilization based on the economic utility of a skeletal element and density mediated survival of a skeletal element.

7.5.1 Bison economic utility

In order to evaluate the utility of an anatomical element factors such as meat weight, transportability, and fat content have been used. From this there have been a number of utility indices developed in the hopes of predicting which portions of a carcass were most valued by the hunter that was butchering it. A series of economic utility indices were devised by Binford (1978) to estimate the value of different portions of caribou and sheep. It used the meat weights and the percentages of marrow fat and bone grease fat from one adult male caribou, one adult female sheep in poor condition, and one juvenile sheep. Although indices were developed based on meat and grease utility

specifically, the general utility index (GUI) was developed to combine all the available resources simultaneously. The modified general utility index (MGUI) was developed to compensate for butchery patterns that involved transport of articulated portions rather than just single elements. (Binford 1978:72). This acknowledged that a low utility food items may be transported as a "rider" because it is attached to a skeletal part of higher utility.

Interpretation of the results of a plot of the %MAU of the skeletal elements to their corresponding MGUI produces two separate patterns. The "reverse utility curve" occurs when there are low frequencies of carcass parts with high food value and high frequencies of carcass parts with low food value. The "gourmet utility curve" results from high frequencies of high food value carcass parts and low frequencies of carcass parts with low food value (Binford 1978: 77-81). The resulting curves are thought to be the result of not only the exploitation of an animal carcass but the type of site associated with the carcass. A kill-butchery site is more likely to have mainly skeletal parts of low utility while an assemblage from a residential-consumption site would contain more high utility food items (Lyman1992:8).

Binford's indices were considered valid for large ungulates and were used in the evaluation of bison assemblages but more recently Emerson (1990) and Brink and Dawe (1989) have developed utility indices for modern bison. The indices developed by Emerson (1990) take a number of carcass components into account including: total meat and individual muscle weight, fat and other tissue weight, de-muscled bone weight, bone marrow and bone grease weight, marrow cavity volume, dry bone weight, bone density and volume measurements (Emerson 1990:178). The data were derived from four bison

of various sex, age and nutritional state. This variation allowed for the creation of several different indices to account for differences in herd structure.

The Utility indices of Brink and Dawe (1989) were designed to evaluate the economic utility of bison bones alone. Their study used three bison that were mixed in age and sex. They used only the bones to evaluate the fatty acids, dry bone and moisture that come from each bone portion. They also measured the size of the marrow cavities and the weight of the marrow plug. Unlike Emerson, they did not divide long bone utility into proximal and distal ends. They divided the bone into the proximal articular end, the shaft portion, and the distal articular end. They did not include any soft tissue in the calculation of the indices.

Two indices were developed from the data. The grease index (GI) was a measure of the percentage of fatty acids multiplied by bone volume, divided by 100. The bone utility index (BUI) combined the bone marrow and grease values into a single index. The two values were combined as it is often difficult to differentiate between grease rendering and bone marrow extraction in the archaeological record. Brink and Dawe (1989:139) considered the cracking of bones for the recovery of marrow and the smashing of articular ends for grease as an integrated process. The BUI is the percentage of fatty acids by the bone portion volume which is divided by 100.

The Sanderson site assemblage was evaluated using these different utility indices in order to distinguish any processing strategies at the site. The %MAU of the assemblage was used as a measure of the relative frequency of elements in the assemblage.

7.5.2 The General Utility Index

Emerson created a number of utility indices for bison based on different sexes and ages. Of these many tables only the standardized modified averaged data total products model, (S)MAVGTP can be used with the Sanderson site bison materials. There are only a limited number of long bone and compact bones that can be assigned any semblance of sex. If only these elements are used then only a very small portion of the assemblage can be used to evaluate the more sex specific indices. If, on the other hand, the assumption is made that the assemblage represents a mixed herd of bison then the indices can be used to evaluate the entire sample. Emerson used whole elements in the evaluation of the utility of an element. For this reason the highest %MAU of a portion of the element was used for the entire element. This is not necessarily a valid assumption though. Since utility of an element is based on the entire element. If only a portion of the element is found and can be identified by a remaining landmark it may cause an over representation of the %MAU of an element which was heavily utilized. Emerson's indices evaluate a faunal assemblage on what was discarded or not used at a site. For this reason two comparisons were made of the Sanderson site faunal material. One was based on landmarks on the long bones to calculate the %MAU of the bone element. The other was based on the counts from complete proximal and distal ends found from those same long bones. As indicated in table 7.1 this can lead to a very different representation of elements in the faunal assemblage.

Table 1 in Appendix IV shows the different %MAU values used for occupation one and occupation two. Table 7.7 summarizes all of the Spearman's Rank Correlation Coefficients calculated for all of the different indices. The use of complete elements in

occupation one results in a stronger negative correlation (r=-0.26564, N=26) while the use of landmarks makes for a stronger negative correlation (r=-0.2169, N=26) in occupation two. Neither correlation is particularly strong or statistically significant and it is likely the result of underrepresentation of elements which rank low in the index. The actual element underrepresentation will be discussed at the end of this analysis. The two graphs (Figure 7.2 and Figure 7.4) plotted from the complete element data show the reverse utility curve that is typical of sites where all elements of higher utility have been removed from the assemblages. The lines on the graphs were plotted using DataFit software version 4.0.7 by Engineered Software. The lines were based on the Holliday non-linear reciprocal quadratic: $\frac{1}{(a+b^{x}x+c^{x}x^{2})}$ This quadratic equation could be solved for all of the graphs and provided good graphical representation of the variables. The correlation between the %MAU and the (S)MAVGTP is not very strong nor statistically significant indicating caution is necessary when evaluating a site merely on graphical depiction. Figures 7.3 and 7.5 are alternative plots based on element underrepresentation and will be discussed later.

7.5.3 Bone Marrow and Bone Grease Indices

The weak correlation of Emerson's (S)MAVGTP and the %MAU of the assemblage may be related to the type of processing that was occurring at the Sanderson site. Bone grease and marrow may have been the focus of subsistence activities and therefore comparison of the assemblage with indices that focus on those activities may be more appropriate.

Figure 7.2 Occupation one %MAU (Complete) vs (S)MAVGTP with non-linear regression line plotted based on reciprocal quadratic.

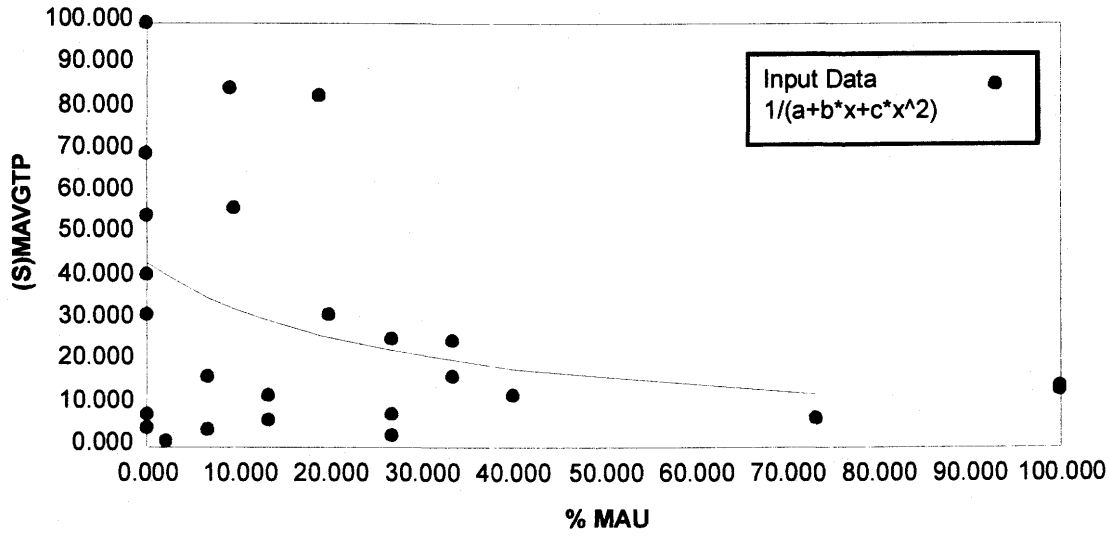


Figure 7.3 Occupation one %MAU (complete) without metapodials vs (S)MAVGTP with non-linear regression line plotted based on reciprocal quadratic.

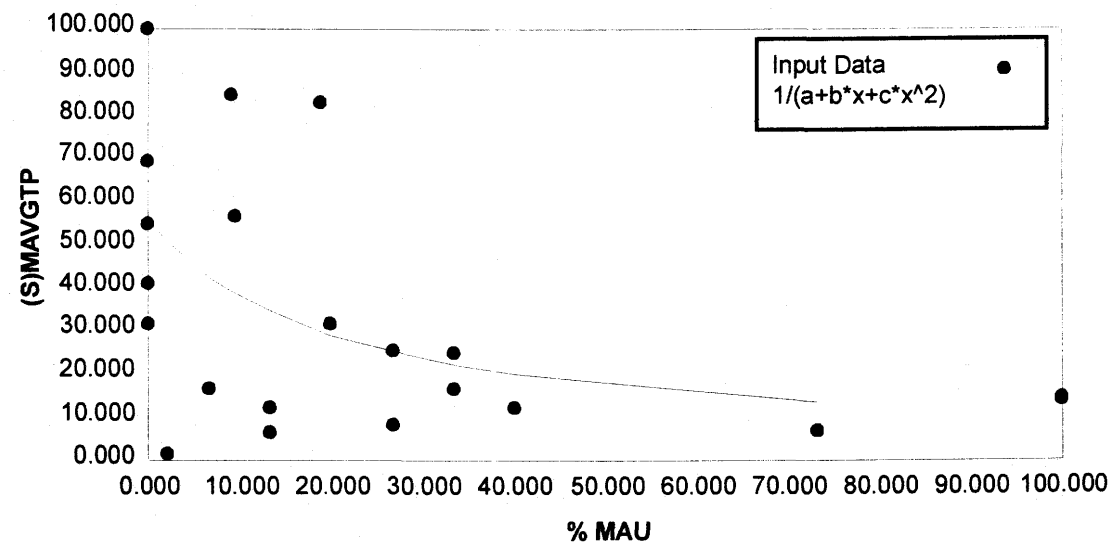


Figure 7.4 Occupation two %MAU(Landmark) vs (S)MAVGTP with non-linear regression line plotted based on reciprocal quadratic.

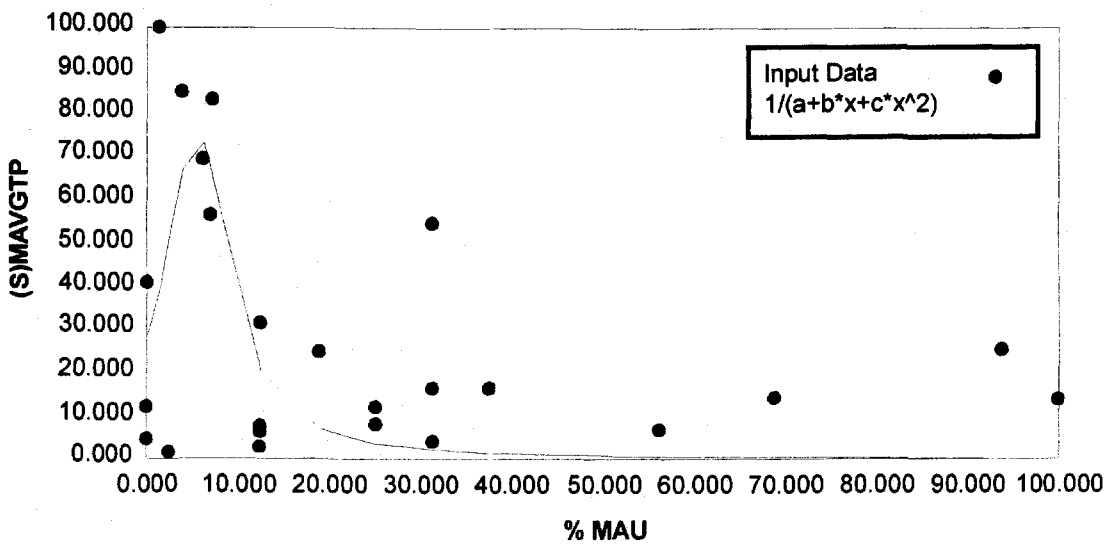
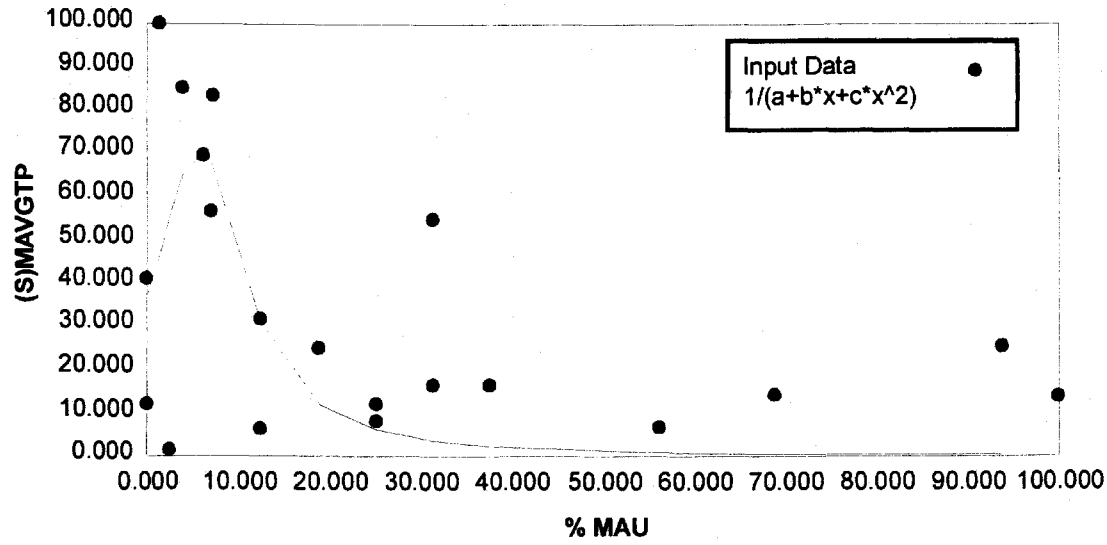


Figure 7.5. Occupation two %MAU (Landmark) without metapodials vs (S)MAVGTP with non-linear regression line plotted based on reciprocal quadratic.



To determine if grease processing was important at the Sanderson site two indices, Emerson's (1990: Appendix C, Table 17) standardized modified averaged grease fat model ((S)MAVGGRE) and Brink and Dawe's (1989:Table 20) revised grease index were used for the methods of comparison. There are differences in the way that these indices are designed, making it necessary to evaluate the Sanderson site with both of them. The sample size and composition used in the indices varied as did the portion of the limb that was used to define the grease value for a limb. Emerson divided the limb into proximal and distal halves with the shaft of the limb included while Brink and Dawe divided the limb into proximal and distal articular ends only. The value of the bone in the indices is measured in caloric yield by Emerson and weight per volume by Brink and Dawe. The comparison was done with both %MAU based on landmarks and %MAU based on complete elements, this includes the shaft portions of Brink & Dawe's revised grease index.

Tables 3 & 4 of Appendix IV present Emerson's (S)MAVGGRE values against the %MAU of both complete bison elements and bison elements based on landmarks. The Spearman's Correlation coefficients are summarized in table 7.7 but it is obvious that the complete %MAU gives a stronger negative correlation in occupation one ($r=-0.3537$, $N=16$) but again the %MAU based on landmarks gives a stronger negative correlation in occupation two ($r=-0.1052, N=16$). The lack of strong correlation or statistical significance indicates that something is biasing the analysis of the grease extraction process. This is not the result of elements that are high in grease potential not being processed but rather elements that are low in grease potential that are missing in the assemblage. This bias will be discussed at the end of the analysis.

Another method of evaluating the grease processing activity at the site is Brink and Dawe's revised grease index. This index was again evaluated based on the %MAU of the bison from complete elements and bone element landmarks. Tables 5 and 6 of appendix IV give a summary of the elements evaluated based on the elements used in the revised grease index. The strongest correlation from occupation one came from the use of complete element counts ($r=-0.2885$, $N=12$) while the strongest correlation from occupation two came from the %MAU based on landmarks ($r=-0.4073$, $N=12$) yet neither of them are statistically significant. This is the identical bias that occurred using Emerson's grease indices and is likely caused by the same problems in element counts. Figures 7.6 and 7.7 represent the best correlations with Brink and Dawe's revised grease index. They represent the most successful use of this index and the exclusion of the metapodials from these figures will be discussed later.

The purpose of both these indices is the evaluation of the importance of grease in limb elements. Yet there are differences in the correlation of the Sanderson site material with the two different grease indices. It is possible that the different construction of both the indices is responsible for the differences between the relationships of %MAU and the grease yield of an element. There is also a possibility that the different populations used to construct the indices account for the differences. It may be that the population used by Emerson more closely approximates the population found at the Sanderson site. The different ranking of some skeletal elements could also have an effect on the way the models relate to the assemblage. This will be discussed in more detail later in the analysis.

Figure 7.6 Occupation one %MAU (Complete) without metapodials vs Brink and Dawe's Revised Grease Index with non-linear regression line plotted based on reciprocal quadratic.

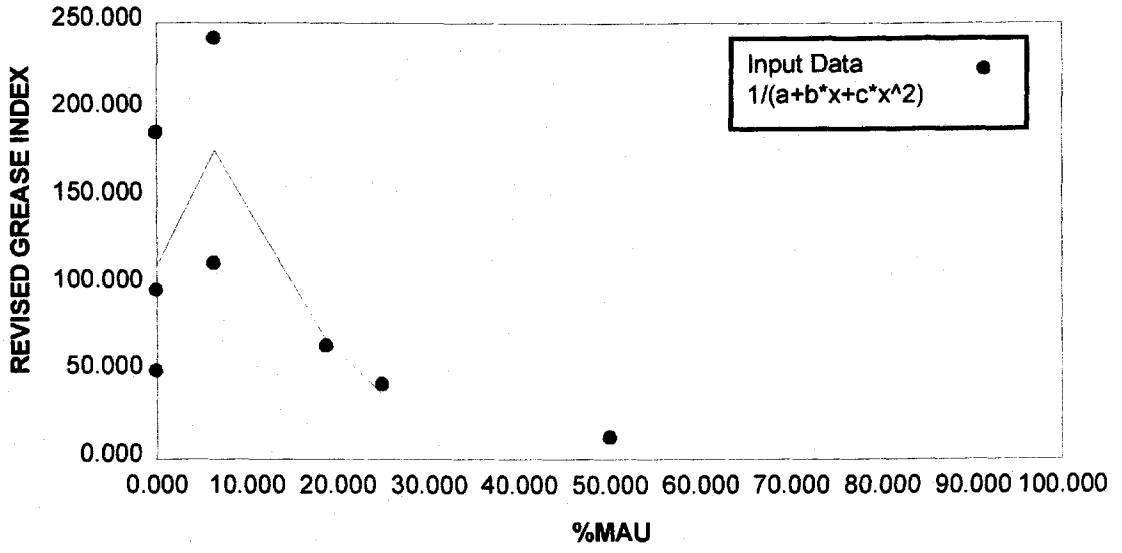
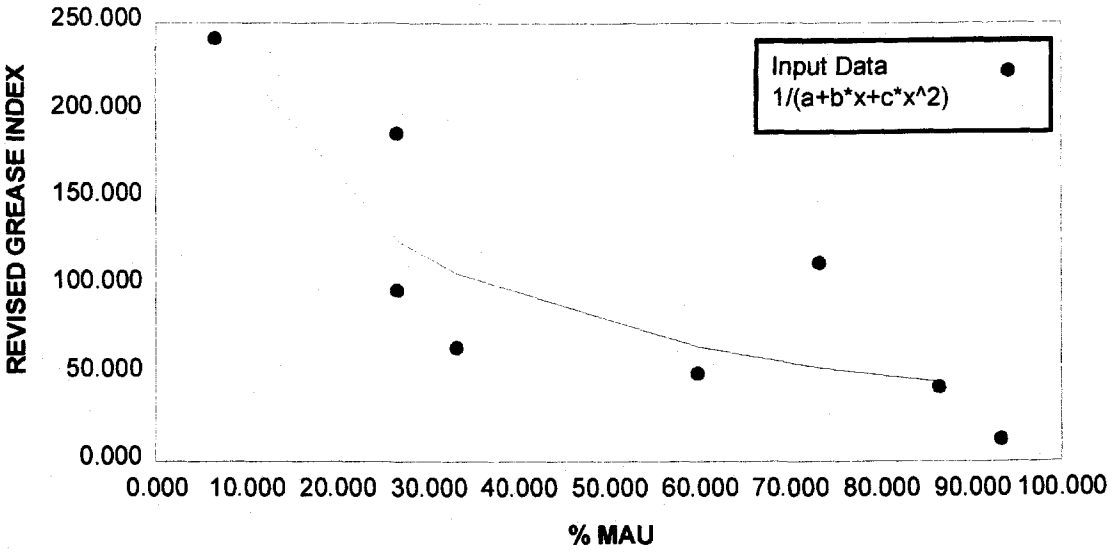


Figure 7.7 Occupation one %MAU (landmark) without metapodials vs Brink and Dawe's Revised Grease Index with non-linear regression line plotted based on reciprocal quadratic.



The last set of indices are those that evaluate marrow processing as an economic activity. Emerson (1990:Appendix C, Table 12) developed the marrow utility index, (S)MAVGMAR, using the proximal and distal ends of long bones. This was not considered a realistic approach by Brink and Dawe (1989:137) who argued that the marrow cavity of a bone was considered as a whole unit and was not discriminated against based on the proximal or distal half of that cavity. They believed that a measure of complete as opposed to broken shafts provided a more accurate estimate of the effects of bone marrow processing.

The values for Emerson's (S)MAVGMAR values and the %MAU for the Sanderson site are presented in tables 8 & 9, appendix IV. Negative correlation was highest in occupation one using the complete element %MAU ($r=-0.1294$, $N=16$) while it was highest in occupation two ($r=-0.1721$, $N=16$) when based on %MAU calculated on bone landmarks. Neither of the low correlations were statistically significant. The negative correlation in occupation one is not difficult to explain as the elements with the highest rating in the index, the proximal femur, distal femur and proximal tibia, were very low. The second occupation requires a bit more explanation. Not only did the highest ranked elements on the marrow index have very low counts for %MAU based on complete elements and landmarks but the %MAU based on complete elements also had very low counts for complete elements with low ranking on the utility index. Fragmentary evidence allows them to appear when the %MAU based on landmarks is used. Although there is a difference in the significance the Spearman's Correlation Coefficient based on complete element counts remains the only valid measure. Fragmented evidence could inflate the count based on landmarks as marrow processing

only requires the opening of the marrow cavity, leaving ample intact bone fragments which could be identified by the competent anatomist.

Although Brink and Dawe (1989: 140-142) did not consider it possible to create a separate bone marrow index they did combine marrow values with grease values in order to create the bone utility index (BUI). This index uses the values from the revised grease indices for the amount of grease in the articular ends of the long bones. The only difference from that index is the evaluation of the amount of fat contained in the shaft of the long bone. This is a combination of the amount of fat found in the bone tissue and the amount of fat in the marrow from the shaft cavity. The summary of the %MAU and index values for BUI are in table 9 & 10, Appendix IV. Occupation one of the Sanderson site exhibits one of the strongest negative correlations for BUI of complete elements ($r=-0.2405, P<0.05, N=18$) after the revised grease index. Occupation two does not have such a strong negative correlation ($r=-0.1001, P<0.05, N=18$) based on complete elements and is close to most of the other indices in level of correlation. All of the utility indices based on landmarks and complete elements are summarized in Table 7.7. The table indicates that most of the indices have a poor correlation to the Sanderson site assemblage. The lack of statistical significance in most of the indices eliminates their usefulness in discussing the taphonomy of the assemblage.

7.5.4 Skeletal element underrepresentation effects

None of the utility indices provide very strong correlations, either positive or negative. There are a number of biases that could have caused these poor results. Many of them are outlined by Emerson (1990:669-670). It is possible that the population

Table 7.7 Comparison of Spearman's Rank Correlation Coefficient for the Sanderson site using different indices and under different analytical conditions. (N = number of portions used, Rho = Spearman's Rank Correlation and P= statistical significance at the 95% level).

Index	N	Rho	P
Occupation one			
Revised grease index(complete)	12	-0.28846	n.s.
Revised grease index (landmarks)	12	-0.22902	n.s.
Revised GI (complete) w/o metapodials	8	-0.65476	<0.05, >0.01
Revised GI (landmarks) w/o metapodials	8	-0.82738	<0.05, >0.01
BUI (complete)	18	-0.24045	n.s.
BUI (landmarks)	18	-0.07379	n.s.
BUI (complete) w/o metapodials	12	-0.51049	<0.05, >0.01
BUI (landmarks) w/o metapodials	12	-0.72203	<0.05, >0.01
(S)MAVGTP (Complete)	26	-0.26564	n.s.
(S)MAVGTP (Landmarks)	26	-0.08838	n.s.
(S)MAVGTP (Complete) w/o metapodials	22	-0.52569	<0.05, >0.01
(S)MAVGTP (Landmarks) w/o metapodials	22	-0.24562	n.s.
(S)MAVGMAR (Complete)	16	-0.12941	n.s
(S)MAVGMAR (Landmarks)	16	0.23382	n.s
(S)MAVGGRE (Complete)	16	-0.35368	n.s
(S)MAVGGRE (Landmarks)	16	-0.06029	n.s
(S)MAVGGRE (Complete) w/o metapodials	12	-0.71154	<0.05, >0.01
(S)MAVGGRE (Landmarks) w/o metapodials	12	-0.28846	n.s
Occupation two			
Revised grease index(complete bone portions)	12	-0.13986	n.s
Revised grease index (landmarks)	12	-0.40734	n.s
Revised GI (complete) w/o metapodials	8	-0.51786	n.s
Revised GI (landmarks) w/o metapodials	8	-0.42857	n.s
BUI (complete)	18	-0.1001	n.s
BUI (landmarks)	18	-0.05212	n.s
BUI (complete) w/o metapodials	12	-0.31294	n.s
BUI (landmarks) w/o metapodials	12	-0.11189	n.s
(S)MAVGTP (Complete)	26	-0.0612	n.s
(S)MAVGTP (Landmarks)	26	-0.21692	n.s.
(S)MAVGTP (Complete) w/o metapodials	22	-0.34839	n.s.
(S)MAVGTP (Landmarks) w/o metapodials	22	-0.37239	<0.05, >0.01
(S)MAVGMAR (Complete)	16	-0.10956	n.s.
(S)MAVGMAR (Landmarks)	16	-0.17206	n.s.
(S)MAVGGRE (Complete)	16	0.05588	n.s.
(S)MAVGGRE (Landmarks)	16	-0.10515	n.s.
(S)MAVGGRE (Complete) w/o metapodials	12	-0.40734	n.s.
(S)MAVGGRE (Landmarks) w/o metapodials	12	-0.35315	n.s.

sample that the indices are based on and the population of the Sanderson site are so different that the indices simply do not work. There could have been a difference in the butchery units used in the indices and the actual butchering units used at the Sanderson site. There could have been transportation decisions that were not predicted by the indices. It is possible that animals of different sex and age were treated differently in the butchering process.

All of these factors could lead to an under or over representation of certain skeletal elements which would not be predicted by the indices and result in a poor correlation between the two. At the Sanderson site the metapodials, the metacarpals and metatarsals seem to have this effect on the indices (Table 7.8). This is also evident in their graphical presentation (Figures 7.2-7.5). These elements are generally ranked low in most of the indices, they have no meat value, a low grease value, and a moderate marrow value. Despite this they seem to be missing from the site in levels far higher than would be predicted. To estimate the effect of this on the site the correlations were re-calculated without the metapodials to see if there was any significant effect.

It was necessary to decide on a statistical measure that could measure the difference as no established statistical method existed in the current literature. First it was necessary to see if it was valid to use a parametric analysis method on the sample. A parametric analysis is more sensitive to variance but can be invalidated if the sample is small or not normally distributed. For this reason the sample was subjected to the

Table 7.8. Summary of Spearman's Rank Correlations for the Sanderson site calculated both with and without metapodials.

OCC 1	w metapodials	w/o metapodials
Revised grease index(complete bone portions)	-0.288462	-0.65476
Revised grease index (landmarks)	-0.229021	-0.82738
BUI (complete)	-0.240454	-0.51049
BUI (landmarks)	-0.073787	-0.72203
(S)MAVGTP (Complete)	-0.168376	-0.41615
(S)MAVGTP (Landmarks)	-0.088376	-0.24562
(S)MAVGGRE (Complete)	-0.353677	-0.71154
(S)MAVGGRE (Landmarks)	-0.060294	-0.28846
OCC 2		
Revised grease index(complete bone portions)	-0.13986	-0.51786
Revised grease index (landmarks)	-0.407343	-0.42857
BUI (complete)	-0.100103	-0.31294
BUI (landmarks)	-0.052116	-0.11189
(S)MAVGTP (Complete)	-0.061197	-0.34839
(S)MAVGTP (Landmarks)	-0.216923	-0.37239
(S)MAVGGRE (Complete)	0.055882	-0.40734
(S)MAVGGRE (Landmarks)	-0.105147	-0.35315

Shapiro-Wilk W test in Arcus Quickstat software in order to test for normality. The sample was classed as negative for non-normality which does not assume that there is a normal distribution in the sample, merely that a parametric method is applicable to the data.

The parametric method chosen was the unpaired (two sample) student t test for the comparison of means. This method tests the null hypothesis that the population means relating to two independent, random samples from an approximately normal distribution are equal. Arcus Quickstat was again used as it could provide warnings if there was a significant difference between the variances of the two samples which would require the choice of another method.

Both occupation one and occupation two had a highly significant difference between correlations calculated with metapodials and those calculated without the metapodials (Occ 1 Mean with metapodials= -0.1878059, Mean without metapodials= -0.5470542, 99% confidence interval for difference between means = 0.105874 to 0.612623, One sided P = .0004; Occ 2 Mean with metapodials = -0.1283507, Mean without metapodials= -0.3565653, 99% confidence, interval for difference between means = 0.038564 to 0.417865, One sided P = .0015). The test was valid as no significant differences in the variance between population means were detected. It is apparent that something is acting on the metapodials that none of the indices were designed to predict. It could be that they were being transported elsewhere for storage or processing. In Nunamiut culture the feet and metapodials were cached over the winter until enough were gathered to prepare marrow cakes (Binford 1978:156). It is also possible that they were undergoing some kind of destructive processing during butchery that could not be predicted by their ranked value. Many Alaskan cultures would resort to smashing bones along the shaft and twisting them off a carcass if the animal had become frozen overnight, making the use of a knife impossible (Binford 1978:50). The metapodials are not the only element which cause poor correlation in the indices. The different ranking given to the distal tibia by the (S)MAVGGRE of Emerson and Revised Grease Index of Brink and Dawe shows up in a difference in the Spearman's Rank Correlation of %MAU calculated by landmarks and complete elements. In occupation one the correlation calculated without the metapodials and based on landmarks is actually higher than that calculated for complete elements. This is due to the low ranking given to the distal tibia by Brink and Dawe. There are fewer complete distal tibia, enough to give

the higher count given by landmarks a better negative correlation. Emerson's higher ranking of the distal tibia negates this problem and results in the %MAU based on complete element to have a better negative correlation than that calculated by landmarks. It is obvious that the calculation of %MAU and the identification of under represented elements are critical to the evaluation of the various utility indices.

7.5.5 Summary of Bison Utility Indices

The use of utility indices at the Sanderson site was not a simple strategy. There were a number of different variables and biases which needed to be addressed in order to find any sort of pattern in the faunal assemblage. Despite this it seems that a bulk recovery strategy as opposed to a gourmet strategy was occurring at the Sanderson site. The (S)MAVGTP model had statistically significant negative correlation in both occupation one and occupation two. The rarity of highly ranked elements such as ribs, proximal and distal femur, innominate and proximal tibia within the Sanderson site established this correlation. Unfortunately a number of elements of low utility such as the metapodials and the distal tibia were underrepresented. This had an opposite effect and weakened the strength of the correlation. The grease indices which had a narrower focus on the activities at the site had the strongest correlations. Brink and Dawe's Revised Grease Index had the highest negative correlation in occupation one (Revised GI [landmarks] w/o metapodials $r=-0.827381, P<0.05, N=8$) while Emerson's (S)MAVGGRE is close behind ([S]MAVGGRE [Complete] w/o metapodials $r=-0.7115, P<0.05, N=8$). If only the %MAU calculated on complete bones is used then Emerson's indices rank highest. The differences are the result of under-representation of

elements and the difference between some values on the same skeletal element. In occupation two the correlation are not as strong but Brink and Dawe's revised grease index yields the highest correlation again (Revised GI [complete] w/o metapodials r=-0.5179, N=8) while Emerson's index also provides a good negative correlation behind this ([S]MAVGGRE [Complete] w/o metapodials value r=-0.4073, N=12). Neither of the grease index correlations from occupation two were statistically significant. This indicates the destruction of low ranking elements was much more prevalent than in occupation one.

Although there was little significant correlation in many of the indices tested the two indices that provided the strongest and most significant relationship were the grease indices. The differences in the correlation of the two different indices may be the result of different bison samples being used to construct the models.

7.5.6 Canid economic utility

Canids have often been regarded as a food source that was used during the late winter and spring when caches of food from the fall were depleted and wild game was in poor condition due to winter stress (Synder 1991:370). The loss of fat in the diet could produce protein poisoning, a condition that could become lethal as the body is unable to process ingested meat protein without enough accompanying fat. During the winter months it is natural for many plains animals such as bison, beaver and deer to lose as much as 90% of their body fat (Synder 1991:372). During this time it has always been assumed that the dogs kept by many Plains groups maintained their body fat by living off the refuse of the camp. The maintenance of these body fat levels has often been assumed

without any substantial proof that they did not suffer the same losses as other animals during the winter season. In fact, among wild canids, the seasonal variation in body fat has a much different pattern than many other wild animals. They tend to keep their fat reserves through the winter and begin to lose them only during the spring. This pattern occurs in wolves, coyotes and foxes. Figures 7.8 and 7.9 show the relative differences in fat levels in canids and ungulates. The raw data do not allow for a direct comparison of fat levels in terms of percent body weight but using g fat/100 g meat for the ungulates and percentage body fat for the canids a good comparison is allowed.

The higher fat levels in canids over the winter months is related to altered metabolic rates which may be triggered by the change in photoperiod (Poulle et al

Figure 7.8. Seasonal fluctuation in percent body fat in *Canis latrans*. Data from Poulle et al 1995.

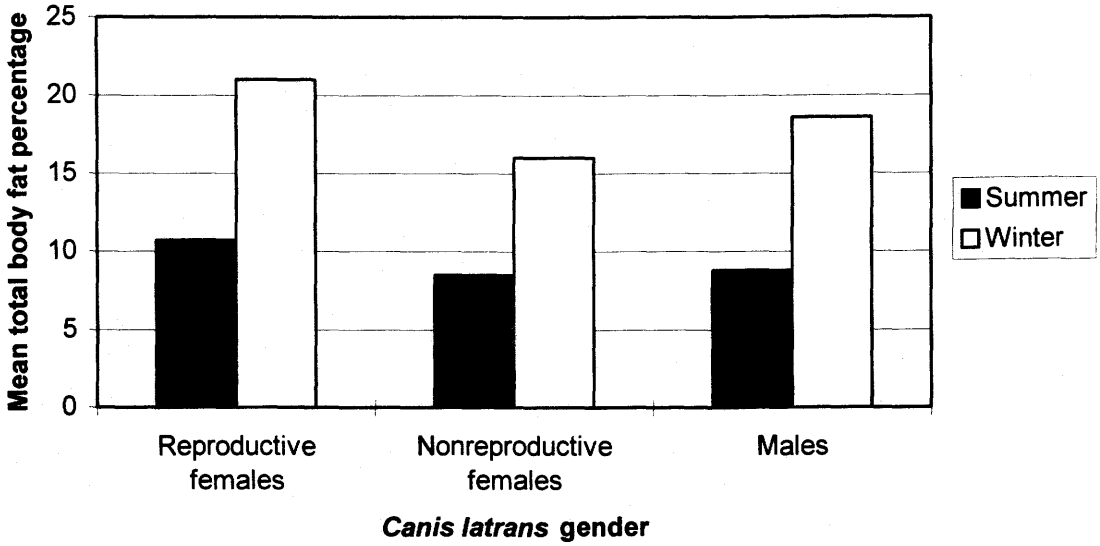
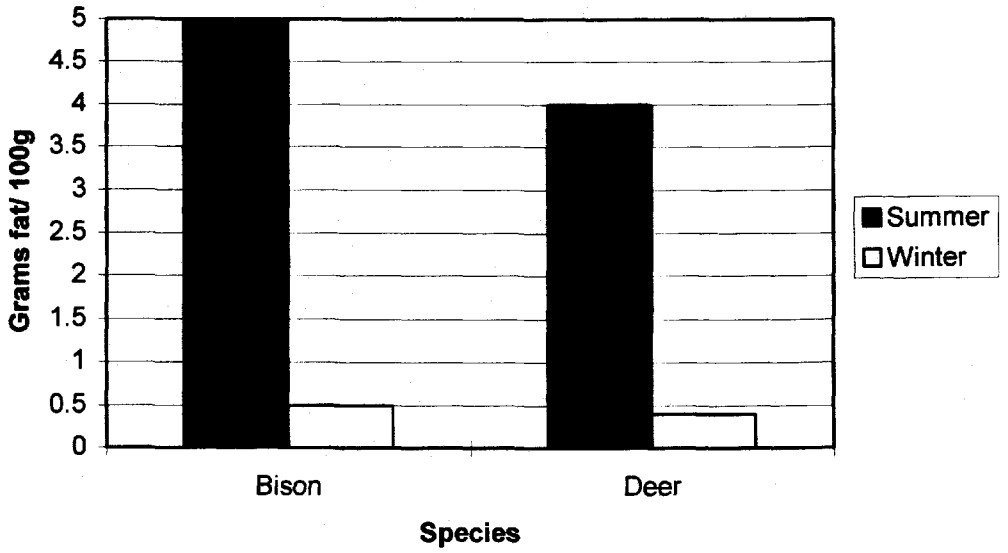


Figure 7.9. Comparison of estimated seasonal fluctuation in fat levels for *Bison bison* and *Odocoileus* sp.. Data from Synder 1991:374.



1995:1631). This affects all animal species including northern ungulate species in which the change in photoperiod of the late autumn triggers a significant increase in lipogenesis (Verme 1988:67). This change in fat levels is not likely due to the subcutaneous deposits assisting in thermoregulation but rather allowing survival during periods of food scarcity. A wild canid can survive for a number of days between feeding on the fat and protein deposits within its body and then rapidly replace them when food becomes more abundant. Ungulates, on the other hand, undergo a steady decrease in fat levels over the winter. The fat reserves of canids begin to decrease in the spring during lactation for the females and territorial maintenance for the males. By summer the reserves are quite low which would reduce the metabolic maintenance costs for the animal (Poulle et al 1995:1631). Unlike many of the utility indices developed for ungulates the fat levels used in these comparisons look at the entire carcass. Considering the size of canids and

processing methods that usually involved cooking the entire carcass at once, the use of overall fat levels is not invalid as an assessment of their importance.

If this change in metabolism occurred in the domestic canids as well, then the animals would increase and maintain their fat deposits over the winter, even if they occasionally went hungry. Considering the numerous references to the interbreeding of wild and domestic canids (Reher & Frison 1980, Walker & Frison 1982) it seems likely that this metabolic trait of wild canids still existed in the Native domestic dog population and would have been a very desirable attribute to maintain.

7.6 Bone Density

There is also a relationship between the utility of a bone and its volume density. The reverse utility curve seen in the utility indices could be the product of density-mediated survival of skeletal portions. Differential destruction caused by carnivore action, trampling, weathering, fluvial transport and sediment loading can then have as large an effect on the faunal assemblage as any cultural activity (Grayson 1989:650). For this reason it is necessary to analyze the faunal remains at an archaeological site on the basis of its density and not just its utility indices.

The use of discrete bone landmarks to identify bone allows an evaluation of different parts of a single element rather than the whole element itself. The landmarks used for the Sanderson site were based on Morlan's (1994b) coding system and could in turn be correlated to bone density scans sites on the bone. Kreutzer (1992:271-274) derived the volume bone mineral densities for several bison skeletal elements using dual energy X-ray densitometry. The scan sites on the bone were designed to compare the bison information with data derived from a similar study done on deer (Lyman 1984). In

evaluating the Sanderson site faunal assemblage the volume density (VD) was used as it is the one measure which deals with the scan site thickness and adjusts the scan results accordingly. In this way a thick bone with a low density will not score the same as a thin bone with high density.

The highest %MAU for a scan site was used if there were several landmarks located nearby. A complete list of the portions used and their corresponding volume density is represented in Table 1, Appendix III. Spearman's rank correlations were used to study the relationship between the density and survivorship of the elements. Correlations were considered significant at the 5% level. The size of the population used in the test was corrected for by the software in the calculation of the correlation and significance.

As seen in Table 7.9 the only elements which showed any correlation were the calcaneous and femur from occupation two. These two elements appear to have undergone density mediated destruction although how this matches any recognized

Table 7.9. Spearman rank correlation between %MAU and volume density (r is spearman's correlation and P is a measure of statistical significance at the 95% level).

		Occ 1		Occ2	
Element	N	r	P	r	P
Mandible	8	-0.08	n.s.	0.13	n.s.
Scapula	5	0.78	n.s.	0.78	n.s.
Humerus	5	0.08	n.s.	0.6	n.s.
Radius	5	-0.2	n.s.	0.3	n.s.
Ulna	5	-0.43	n.s.	0.1	n.s.
Metacarpal	4	-0.55	n.s.	-0.55	n.s.
Innominate	7	-0.21	n.s.	0.14	n.s.
Femur	6	0.13	n.s.	0.89	<0.05,>0.01
Tibia	5	-0.28	n.s.	-0.23	n.s.
Calcaneous	4	0.4	n.s.	0.8	<0.05,>0.01
Metatarsal	4	0.6	n.s.	0.6	n.s.

butchery or attritional pattern is unknown. It may be that these elements were the only two that had a sufficient number of recognizable landmarks remaining. The negative correlations for many of the long bones are probably related to this factor as well.

One of the problems in using the data from a fragmented site is that the utility and density indices are designed with the whole element in mind. If the proximal humerus can be identified based on a single landmark which has survived it cannot really be considered to have a high %MAU based on its density, since the portion was effectively destroyed. By the same measure the utility of an element portion, such as the proximal or distal halves, is based on its total yield. If %MAU of the portion of the element is based on a single landmark that is part of the overall structure of the portion it cannot be considered a whole portion in the analysis. The portion of the element has obviously been processed, it is simply still visible in the assemblage because one landmark was spared through processing technique or differential density. The utility of an element can only be considered if that element is effectively intact, indicating that either human economic choices or bone density left the bone intact in the archaeological assemblage.

7.7 Natural Forces

7.7.1 Weathering

Bone weathering is a combination of physical and chemical processes (Behrensmeyer 1978). The visible effects on the bone include cracking, splitting, exfoliation, disintegration, and decomposition. The intensity of this weathering may or may not give an indication of the amount of time the faunal assemblage was exposed before it was buried in sediment (Behrensmeyer 1978). Multiple variables such as moisture, temperature, and direct sun exposure can affect the rate of bone weathering

(Lyman and Fox 1989:313). Human activities such as burning and boiling can also affect the bone surface by altering the crystalline structure of the bone itself and creating artificial weathering effects (Stiner and Kuhn 1995). The physical structure of the bone can also affect its weathering behaviour. Smaller compact bones have a higher density and tend to weather more slowly than other more delicate elements.

Based on the bone weathering criterion of Todd et al. (1987 Table 3.3) the Sanderson site does not exhibit a high degree of weathering or deterioration. Figures 7.10 to 7.13 demonstrate the level of weathering based on six weathering stages for both cortical and compact bone. The elements that were picked for sampling represent the most complete and numerous elements in the assemblage. This was designed to control for any differences in bone structure and density that could cause differential weathering between the elements. The occupation one weathering profile exhibits a low level of weathering in both the cortical and compact bone. The level of cracking of the surfaces is extremely low indicating limited surface weathering. The microfractures that do appear

Figure 7.10. Weathering profile of compact bone sample from occupation one.

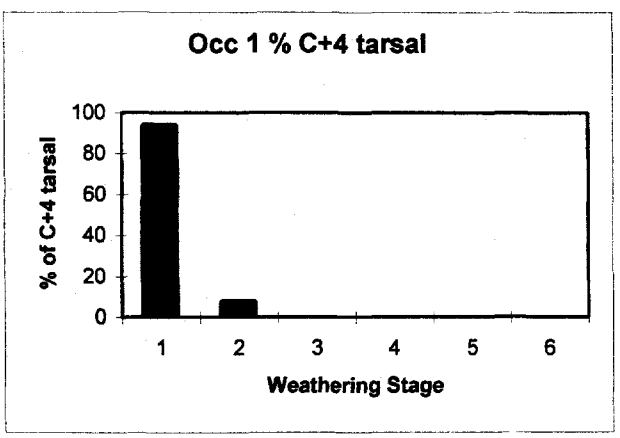


Figure 7.11 Weathering profile of cortical bone sample from occupation one.

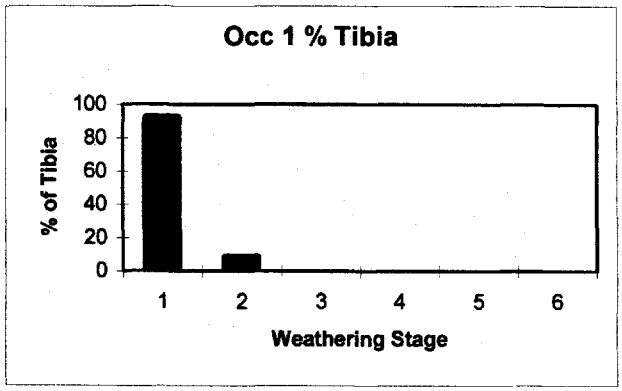


Figure 7.12 Weathering profile of compact bone sample from occupation two.

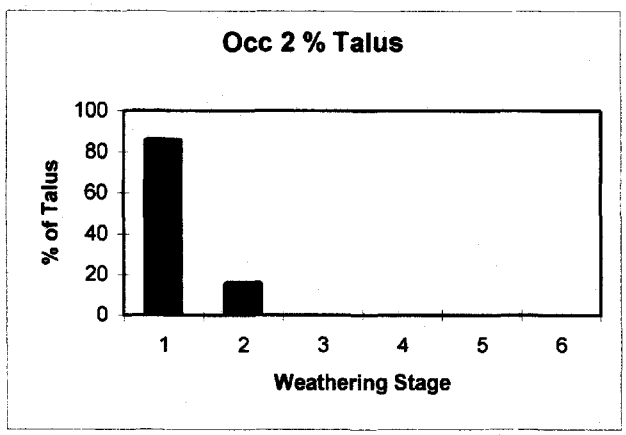
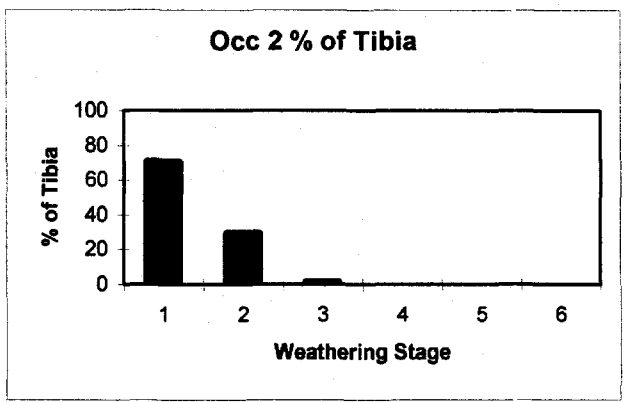


Figure 7.13 Weathering profile of cortical bone from occupation two.



on the many surface are the result of limited exposure of the bone surface to air. These can result from only hours of exposure and do not constitute the longitudinal surface cracking as described by Todd et al (1987: Table 3.3).

The occupation two sample exhibits a higher level of weathering but not to an extreme degree. The cortical bone exhibits a greater degree of weathering than the compact bone indicating that the lower assemblage was likely exposed to a longer period of weathering or more intense weathering that would have affected the less dense cortical bone.

Much of the bone had uniform weathering over its entire surface but there were occasions where one portion of the bone had undergone more extreme weathering. This is likely due to the placement of the bone on a surface where one face was exposed to the elements. The implications of the low level of weathering on the bone are a short period of time exposed to the elements. The frequency and severity of flooding by the Souris River would have provided the sediment necessary to cover the assemblage and stop the weathering caused by exposure to open air. The shade provided by the surrounding forest and the yearly leaf mat would also have contributed to the preservation of the bone.

7.7.2 Abrasion and Polish

Both abrasion and polish involve the removal of bone material from the surface of a specimen. Abrasion involves the erosion of a bone surface through the application of physical force but lacking any polish or sheen (Bromage 1984:173). Polish is the resulting bone surface that is smooth and rounded until it has a gloss or sheen. The two terms tend to be used interchangeably often leading to ambiguity in the description of bone surfaces (Fisher 1995:33).

Abrasion and polish can be caused by a variety of mediums before during or after burial. Water action can abrade the bones by moving them over gravel or hard surfaces or the flowing water itself can carry the abrasive particles. Aeolian action can carry windborne particles which have a similar effect. The yearly break up of the river ice can provide a powerful abrasive force as the ice sheets impact the river's edge. Other possibilities include the heaving action of freezing and thawing, the swelling and shrinking of clays or even treefall (Fisher 1995:34). Trampling by large animals can also cause abrasive effects on bone that is lying on the ground or within loosely consolidated matrices such as sand or moist deposits. This abrasion can often appear as scraping or cutmarks on the surface of the bone.

The Sanderson site could have been affected by a number of these taphonomic factors including water and ice action, freezing and thawing and trampling. The yearly flooding of the area is well documented as is the yearly break-up of ice along the river. The site was originally discovered by the upheaval of bone caused by the trampling action of cattle at the edge of Lake McDonald and in the past bison would have had much the same effect. Although the water's edge is far from Block 7 today it could easily have moved across the site a number of times with fluctuating water levels.

There is no evidence of polishing as defined by Fisher (1995). There is also little evidence of abrasion. Most of the bone surface shows good detail and little evidence of scraping or striations. There are a few that show rounding along the edges of breaks and this could have been caused by any of the factors already mentioned. The lack of abrasion fits well with the spatial distribution evidence which places clusters of bone around known features within the Sanderson site. This indicates that the site was likely

not impacted heavily by the flooding behavior of the river, either in water tumbling and scattering or sediment abrasion. The lack of scattering and abrasion also indicates that the erosive effects of ice flows were not substantial. There is also no evidence of trampling damage among the bone, none of the bone examined microscopically exhibited any of the highly variable striations as described by Fisher (1995:36). It is possible that low level abrasion at the site occurred but was obscured by later surface modification such as root erosion, a much more prevalent problem at the site.

7.7.3 Carnivore attrition

Carnivores, rodents and herbivores will all chew and ingest bones. The kind of damage that can result includes striations, furrows, pits, punctures, ragged edges, chipped edges, sinuous edges, polish, concoidal flake scars, and bone flakes (Fisher 1995:36). The size and shape of the damage is dependent of the shape of the tooth and the species that creates the damage.

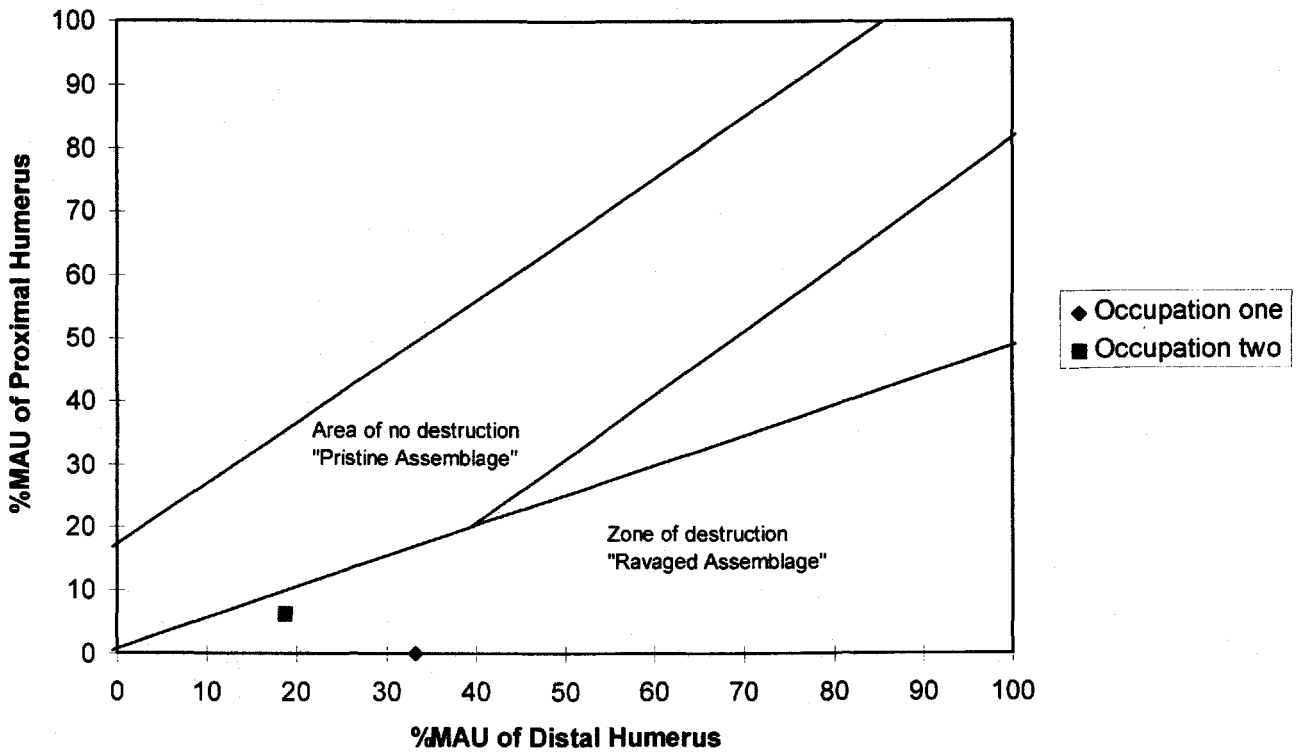
The Sanderson site did not exhibit a large amount of this kind of damage in the assemblage. Less than four percent of either the occupation one or occupation two assemblage showed any signs of carnivore activity but this may be a reflection of bone surfaces that were obscured by root erosion. There was no evidence of rodent or herbivore chewing at all. Despite the appearance of a low impact on the assemblage it is still possible for carnivores to spatially disturb an assemblage and leave no gnaw marks on the bone (Kent 1981:370). For this reason a more detailed look at the destruction of bone portions rather than just surface modification is required to completely assess carnivore impact at a site.

Table 7.3, the comparison of the percent difference between the Sanderson site, other archaeological sites and a wolf kill indicates a pattern that is not typical of a wolf kill site. The level of destruction is simply too high for canids to have affected it without having left significantly more evidence. The degree of bone attrition may be related to the upper strength limit that these carnivores can exert on the robust bones of larger bovids. Bonnichsen (1979:23) experimentally discovered that neither wolves nor Siberian tigers could "break or seriously alter beef bones" indicating that most carnivores on the plains were physically incapable of this level of destruction.

Binford (1981,1978) uses a similar relative frequency of elements within an assemblage to graphically evaluate the impact of carnivores on archaeological sites. His measure, termed the ratio value of an element (Binford 1981:219) or %MNI (Binford 1978:72), which has been used by others (Speth 1983:62), is essentially the minimum animal units from a site measured as a percentage of the largest number of animal units measured. For this reason %MAU will be used in the course of this investigation and translated from existing bodies of information for the purposes of comparison.

Figures 7.14 and 7.15 indicate that the Sanderson site faunal assemblage falls into the "Ravaged assemblage" zone that would have been heavily affected by the destructive action of carnivores. This zone is based on a number of recorded wolf and hyaena kill sites. The "Pristine assemblage" zone is based on a number of ethnographically recorded human kill sites where is was known that carnivores had not affected the site (Binford 1981:221). The Binfordian classification would seem to be incorrect as the direct evidence of carnivore destruction on the bone surface itself is scarce. It may be that the Sanderson site falls into one of the exceptions noted by Binford in this kind of analysis.

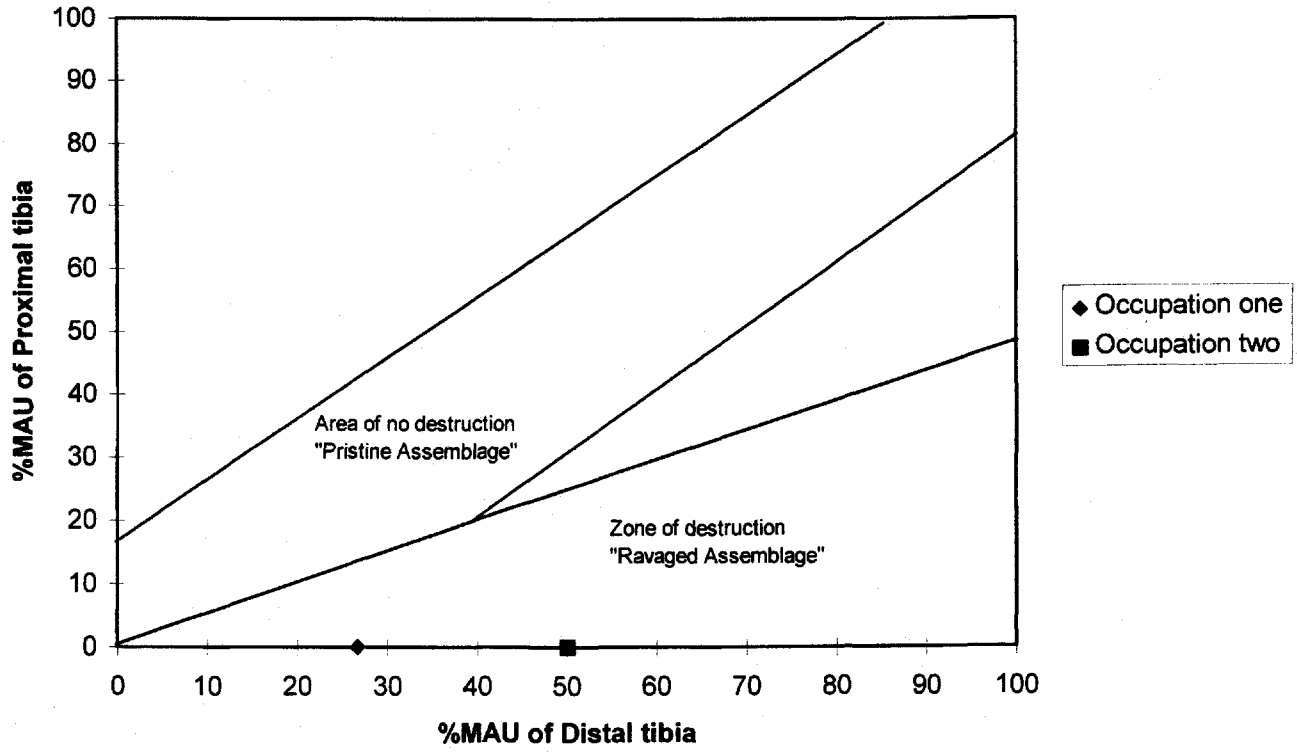
Figure 7.14. Relationship between %MAU of proximal and distal humerus.



Sites where butchery of frozen limbs elements occurred fell into the "Ravaged assemblage" despite absolutely no carnivore activity being recorded. It seems that frozen limb elements were destroyed as the limb was processed in a way that mimicked carnivore destruction. As noted earlier this destruction falls into an area of carnivore destruction and usually exceeds it.

The extreme level of destruction, the limit of plains carnivores to destroy bovid bones and the ethnographic evidence that explains how butchery patterns can mimic carnivore destruction all indicate that carnivore impact on the site was minimal. There was also good correlation between bison distribution and known features within the site,

Figure 7.15. Relationship between %MAU of proximal and distal tibia



again supported culturally created distributions rather that carnivore ones. It seems likely that humans rather than carnivores had the largest impact on the condition of the faunal assemblage

7.7.4 Digestive corrosion

There was little evidence of digestive corrosion among the elements examined. Among the microvertebrate bone assemblage this was especially important as predator action can often add these small bones to a faunal assemblage. The different stages of corrosion described by Stahl (1996) were not evident from visual and microscopic examination of the bone. There are a number of other reasons to indicate that there was

no predator linked concentrations at the site. The bones were burned and although it is possible a natural fire could have created this condition the bones were associated with cultural features. There was no single concentration of bones as would have resulted from their association with the roosting areas of raptors and the bones do not exhibit digestive corrosion damage. However, it is possible that the light microscope may have missed the finer indicators that only showed up under scanning electron microscope (Stahl 1996:53-55).

Among the larger vetebrate species there was also a lack of evidence. This would have shown up as heavy surface corrosion and toothmarks. Most canid and feline scats which have been analyzed display severe corrosion and rounding of bone fragments (Stallibras 1990:155). Bone consumption by these kinds of predators also tends leave highly mineralized faecal material due to their high levels of calcium carbonate. This enhances their chances of recovery within an archaeological context (Stallibras 1990:156). Despite this no such material was recovered with the bones at the Sanderson site.

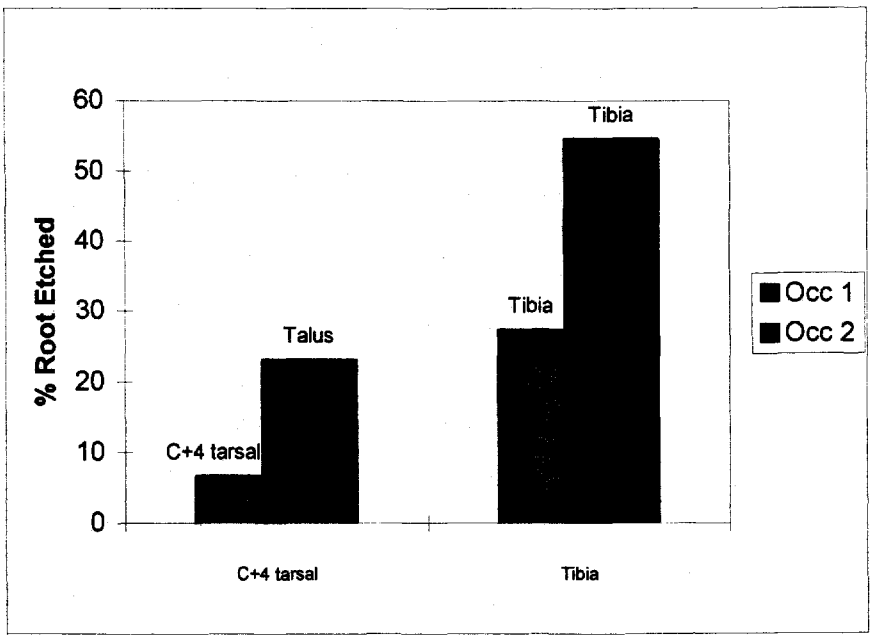
7.7.5 Root erosion

Root erosion represents the shallow lines etched in the surface of bones by acids associated with plant roots (Behrensmeyer 1978). The acids may be derived from the roots themselves or from fungi associated with decomposing roots. Root etching of the bone is visible as multiple lines of a sinuous configuration that are visible to the eye and have a U-shaped cross section (Fisher 1995:43). Pitting can also result from root erosion although it is accompanied by the characteristic sinuous lines so it is not likely to be confused with pitting from other processes.

The area adjacent to the root etching may also become more vulnerable to erosion. The acid from the nearby root erosion obliterates not only the bone but any evidence of its linear configuration, resulting in pits in the bone with no direct evidence of acidic root action.

Figure 7.16 indicates that root etching is more prevalent in occupation two, which is not that surprising as the lower occupation has a longer time depth in the soil matrix and would therefore be subjected to a higher degree of root erosion action. It also seems that the cortical bone exhibits a much higher level of root erosion than the compact bone at the site. This may be related to the density of the bone as well as the smooth surfaces of the cortical bone which make it much easier to detect root action.

Figure 7.16. Comparison of root etching between compact and cortical bones of occupation one and two.

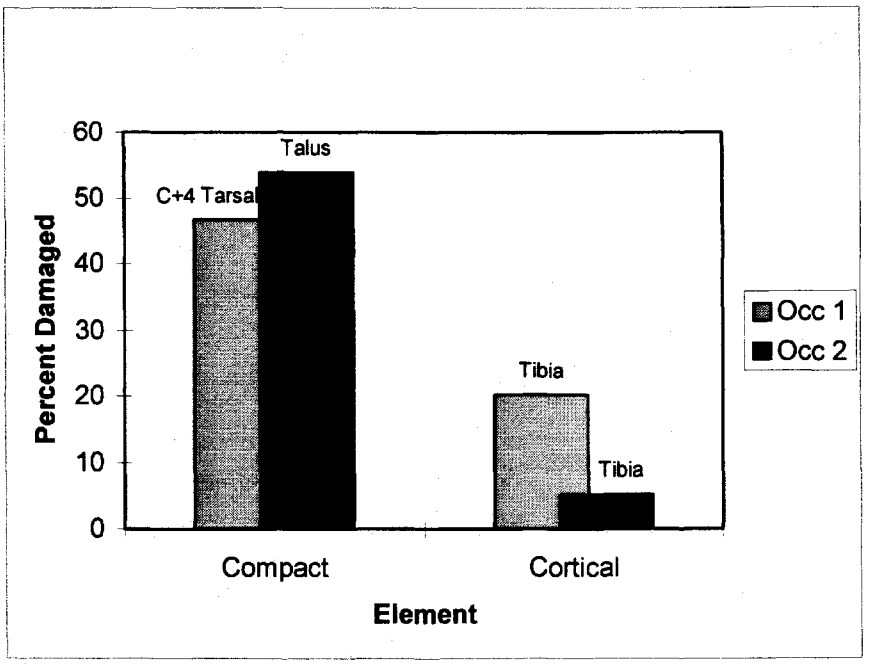


7.7.6 Excavation or Preparation damage

The salvage excavation nature of the Sanderson site required its expedient excavation. There was also the public archaeology aspect of the excavation where untrained workers were allowed to remove materials. Block 7 west only had three levels of one unit excavated in this manner but there is a fair amount of shovel trauma on the bone. In most cases it is very obvious as an area of exposed fresh bone. It is therefore possible to recognize this as the result of modern damage so as not to confuse it with any ancient human activities. The adhesion of matrix to the bone was probably also responsible for the abrasion from cleaning some of the bones exhibit. Again this abrasion was usually obvious as it exposed fresh bone under the stained outer cortex.

Damage was only recorded where a large portion of the bone was missing or damaged. The level of damage is completely random, the difference between the compact and cortical bone sample is therefore difficult to explain (Figure 7.17). The

Figure 7.17. Summary of excavation damage for cortical and compact bone sample.



difference in the level of damage from occupation one to occupation two in the cortical bone is likely due to the greater amount of force required in the shovel excavation of the root mat in the upper levels.

7.8 Cultural Forces

7.8.1 Cutmarks

7.8.1.1 Bison

Cutmarks were not as common as would be expected in the bison assemblage. This may be due to a butchering method that relied on smashing rather than cutting or may simply be a reflection of a level of fragmentation that has obscured much of the evidence. Most of the cutmarks observed are on the carpals and tarsals, not surprising considering they were among the most complete elements in the assemblage.

The few cutmarks that could be found on the assemblage closely resembled those that occurred at the Glenrock Buffalo Jump, a Late Prehistoric Period bison jump. At that site it was assumed that butchery began quickly after the kill was made to avoid losing much of the meat to spoilage and to strip the hides off the animals before they cooled (Frison 1970:8). Based on the butchery patterns and the assumption that the marks on the bone represented some kind of strategic butchery process a sequence of disarticulation was described.

Usually at Glenrock skinning was the first step in the butchery of an animal. This involved cuts around the circumference of the fore and hind limbs of the animal. The only evidence of this kind of cutmark at Sanderson comes from a single fragment of metacarpal from the first occupation. This appears on the anterior surface of the distal

portion of the shaft of the bone and may have continued around the limb but the shaft was only fragmentary so it is impossible to tell.

Other cuts that occurred at Glenrock during the skinning of the animal include a main cut down the top of the back and possibly down the belly (Frison 1970:11). There is no evidence of this on any of the vertebrae recovered from the site but most of these bones were heavily fragmented and any evidence would have been lost.

The next step involved removing the front and rear foot bones by severing ligaments running along the leg. Most of the cutmark evidence from the Sanderson site comes from this step as the marks occur on the carpals and tarsals, elements that survived due to their density and low economic utility. There were cutmarks on the medial and lateral surfaces of radial, ulnar and fused 2nd and 3rd carpals. These cut mark locations correspond to the anatomical locations of the lateral and medial digital extensor ligaments, the main connective tissue that runs past this joint. It is also easier to cut the ligaments at this point as extensor retinaculum forms a tight sheath of membrane which holds the ligaments close to the bone. All of the evidence comes from occupation one in the form of one radial, one fused 2nd and 3rd, and four ulnar carpals exhibiting cutmarks. On the rear leg cuts ran across the medial and anterior surface of the tarsal bone and there were impact marks that showed up on the anterior surface of the bones. The lateral malleolus was the only other hindlimb bone that exhibited any cutmarks. These cuts are consistent with the severing of the digital extensors which run over the anterior surface of the talus and the long lateral collateral ligament which runs over the lateral malleolus. The feet were then snapped off and discarded as they contain little meat. The evidence for rear limb butchery comes mainly from occupation one with two tali and one lateral

malleolus while there was only one talus from occupation two that exhibited any cutmarks.

The butchering sequence of the bison did not stop at this point, but much of the evidence at the Sanderson site has been obliterated. There are a few fragments of long bone which exhibit cutmarks, including two humerus shafts, one radial shaft and one tibial shaft fragment. Most of these cuts are short shallow cuts that would likely have occurred during the removal of meat from the limb. There was one pelvic fragment with cutmarks on it and again this was likely a result of meat removal as there are a number of large muscles which insert on the innominate. There is also one sacral fragment from occupation one which appears to have chopping marks on the anterior portion of the element. These would have been consistent with chopping away the sacral wings and removing the spine, a pattern which also appeared at the Glenrock site (Frison 1970:19).

Most of the evidence for butchery of the skull was lost when the material became heavily fragmented. The only evidence of butchery of the mandible comes from two mandibular condyles from occupation one and one condyle from occupation two. There are cutmarks across the condyles which do not match any described by Frison (1970) but were undoubtably related to the removal of the mandible from the skull. The Nunamiut would remove the mandible at the condyles to serve as a container for the tongue. After transport and removal of the tongue, the mandible would be discarded or kept for further marrow processing (Binford 1978:149). The only cut marks from the skull come from a single premaxilla from occupation one. The removal of the nose as a delicacy has been recorded in ethnographic literature (Frison 1970:22) so the cutmarks are likely related to this kind of butchery.

Most of the cutmarks on the bone are consistent with the complete processing of a bison carcass that was prevalent in the Late Prehistoric Period. The lack of cutmarks on many of the limbs has to do with alternate butchery techniques that involved breaking the limbs apart with smashing blows and secondary processing activities such as marrow and grease processing. This resulted in a highly fragmented faunal assemblage that makes a complete picture of the butchery pattern at the Sanderson site impossible.

7.8.1.2 Canids

The cutmarks among the Sanderson site canid sample are few. Only two were observed, one across a rib and another on the condyloid crest on the lateral aspect of the mandible. The degree of fragmentation and root-etching has likely obscured any other evidence of cutmarks on a number of the elements. The cutmarks on the rib match the disarticulation and defleshing pattern at the Packer site(25SM9) in Iowa (Synder 1991:369). This fits well with the inference that the Sanderson site canids were being processed for food rather than for their furs. The cutmarks on the mandible do not match any recognized butchery pattern. These cuts would have been designed to sever the masseter muscle, the major muscle connecting the mandible to the cranium. This kind of cut was likely not designed for subsistence related butchery as the food value of the skull as a whole was rather low. It was likely that the cranium was being removed from the rest of the carcass for some other reason. The removal of the skull for ceremonial reasons has been documented at other sites (Hayden 1997:100). This may be one of the factors that explains why there were no complete skulls recovered from the site.

7.8.2 Burning

The existence of burning on the surface of an animal bone is not always the result of cultural activity. The grasslands surrounding the Sanderson site would have been a source of seasonal fires which could have swept through the undergrowth of the forested area.

Even if the burning had resulted from cultural activity it would have been a mixture of intentional and accidental damage. In an experiment that looked at the effects of burning on archaeological bone Stiner et al. (1995:230) found that small hearths containing 6 kg of wood could char bone up to five cm below the level of the hearth. Block seven west of the Sanderson site had both shallow deposits and an abundance of large hearths throughout the upper and lower occupation.

Table 5.1 gives a summary of the amount of percentage of bone that was burned at the Sanderson site. Block seven west had 45.54 % of the identified fauna burned and 47.77 % of the unidentified fauna burned. Most of the faunal material was made up of large ungulates, but there were a number of other taxa that exhibited burning including canids, rodents and anatids.

7.9 Summary of Butchery patterns

7.9.1 Bison

The bison material at the Sanderson site exhibits butchery patterns which were common in the Late Prehistoric. The few cutmarks which were visible correspond to the skinning and butchery of the bison while the carcasses were still fresh. The anatomical remains left at the site indicate the kind of reverse utility curve which occurs at kill sites where the richest anatomical portions are carried away to another processing area or camp

site. The selective destruction of bone elements is consistent with grease processing that occurs after the initial butchery. The absence of selected low utility anatomical portions is the one factor that complicates the pattern. If all low utility portions were missing it would be simple to assume that they were consciously discarded at the initial kill site and only the higher yield items were returned to this butchery area. This would not explain how the metapodials seem to be missing from the assemblage while the phalanges are common. It seems that some other form of butchery occurred that cannot be predicted by existing utility indices. Another complicating factor is the presence of articulated limbs at the site. The extreme level of bone destruction seems consistent with the highly efficient processing strategy undertaken in a starvation situation. Under these conditions even low utility bones were destroyed for their grease value. It seems unlikely that these bones would have been used only after the larger articulated units were processed. Some possible reasons for this pattern will be discussed in more detail in the next chapter.

7.9.2 Canids

At the Sanderson site the lack of rib and limb elements indicates that the carcass was undergoing primary processing at the site and the segmented elements were being removed for further preparation and consumption elsewhere. The burned state of many of the mandibles and limb elements indicates that the entire carcass was being burned in the fire before it was segmented. The cranial, mandibular, vertebral and distal limb elements represent the discarded refuse after this initial butchering. In ethnographic accounts a dog was first singed completely in order to remove the fur from the skin and then the carcass was eviscerated and then cut into portions for boiling. These portions were cooked with the bone in and would have included most of the elements missing at the Sanderson site

(Synder 1991:367). Obviously the secondary processing at the Sanderson site differs somewhat from the ethnographic account, but this is not surprising as there are many techniques indicated by the archaeological record (Synder 1991:369). Despite a clustering of canid elements in parts of the site, there is no evidence to support a canid burial or any kind of special treatment of the remains. Usually, intentional burial of canids involved the entire articulated skeleton, and burning and butchering were not part of the process (Kerber 1997:77).

7.9.3 Rodents

Spermophilus sp., *Spermophilus richardsonii*, and *Microtus pennsylvanicus* all exhibited burned skeletal elements. These include some distal limb elements and the incisors in both of the jaws. Morlan (1994c:139) has surmised that the presence of such burning patterns is an indication of human consumption of rodents. A similar pattern occurred at the Tipperary Creek site (FbNp-1) where the burning patterns on rodents were inferred to be evidence of human roasting of small mammals (Morlan 1994c:139).

7.10 Summary

The Sanderson site could be considered to have a good state of preservation but a poor state of completeness. Most of the bone surfaces have been well preserved but their study is inhibited by a high level of fragmentation. Despite this it was possible to do an appraisal of the amount of natural and cultural damage that occurred at the site.

The revised grease indices of Brink and Dawe (1989) and the (S)MAVGGRE values of Emerson gave the best and most statistically significant correlation at the Sanderson site. It is apparent that grease processing had the largest impact on the site and was likely responsible for much of the destruction. It was also apparent that the

metapodials affected the outcome of this correlation. If they had been included there would have been no significant correlation with any of the indices developed. It is obvious that although the grease indices provided the best model for predicting activity at the site there is some part of the butchery process which cannot be anticipated by them.

The lack of significant correlation with the density indices for bison indicates that the high level of destruction at the site is not density mediated. The missing elements which affected the correlation of many of the utility indices were not missing from the assemblage due to density mediated attrition. This supports the idea that a cultural rather than natural factor was affecting the survival of elements in the assemblage.

It was apparent that root etching had a major impact on the surface of much of the bone but most of the bone was not severely weathered by open air exposure. There is also little evidence that carnivores had any sort of substantial impact on the site. There were not enough tooth marks on the bone, and the pattern of destruction did not match any natural carnivore kill situation. The condition of the bone surface did allow for the analysis of cutmarks on the bone and for some conclusions about the sequence of disarticulation. It is difficult to compare the butchery patterns at the Sanderson site with other Mortlach sites as this is the only one to date that has undergone such a detailed faunal analysis. It does seem to fit the pattern of disarticulation seen at other Late Prehistoric Period sites although much of the evidence for this is based on a very small sample of observed cutmarks.

The impact of natural forces on the Sanderson site is minimal compared to the culturally-mediated forces which affected it. Quite simply, nature could not have fragmented the material at the site without leaving more evidence of the natural agency

that caused the destruction. The heavy bone processing that was typical of the Late Prehistoric Period is the primary factor in the formation of the Sanderson site assemblage.

CHAPTER 8

WINTER SUBSISTENCE ACTUALISTIC STUDY

8.1 Introduction

Some unusual patterns of bone fracture appeared within the assemblage at the Sanderson site. For example, slab fractures of the tarsals and carpals are rare for most bone processing, either in marrow or grease rendering. Despite this, a number of such fractures appeared in the bison bone assemblage from both occupation levels. Slab fractures are defined as a split in the bone which extends through both articular surfaces. Brink (1994) does not even mention carpals and tarsals in his grease indices, presumably because the amount of grease that can be extracted is minimal. Jones and Metcalfe (1988:422) mention how undesirable the same parts were for marrow extraction because of the excessive amount of work required for the number of Kcal extracted. There was also an odd mixture of both fresh and dry bone fractures within the assemblage and a high level of fragmentation as indicated by the incompleteness of the bone (Table 7.2).

Morlan (1994a) discusses fracture patterns at the Harder site, an Oxbow bison hunter's camp, as having the same kind of sagittal and longitudinal fractures through the tarsals that were seen at the Sanderson site. He hypothesizes these are the result of the processing of frozen limbs where a transverse force, applied on the shaft of the bone would travel laterally along the limb and through the frozen joints. Presumably the frozen ligaments would secure the joint and any impact absorption from cartilage or joint capsules would be lost (Morlan 1994a:773). The freezing would also create the numerous dry bone fractures throughout the assemblage by altering the biomechanical

properties of the bone. It was suggested that experimental reconstruction is the best way to test this theory (Morlan 1994:773). Therefore an actualistic study into the breakage behaviour of bone under normal and frozen conditions was undertaken.

8.2 Other experimental evidence

There have been a number of experiments carried out in order to evaluate bone breakage under different conditions (Marean 1991, Noe-Nygaard 1977, Sadek-Kooros 1972,1975, Bonnichsen 1979, Bonnichsen & Will 1980, Capaldo & Blumenschine 1994). Most of them were concerned with the replication of breakage patterns seen in archaeological assemblages. For this reason all of them were concerned with the splitting of long bones for the extraction of marrow and the crushing of articular ends for the purposes of grease extraction. Most of these do not discuss the intentional fracture of compact bones during the processing of the animal but some mention it as ancillary to the processing of long bones for the removal of marrow. In looking at the results of these actualistic studies it is important to be cautious. The assemblages from the actualistic studies have not undergone the same post-depositional damage as an archaeological assemblage and must be assessed with this knowledge.

The study of Marean (1991) involved the severe processing of animal limbs by human and carnivore agencies. It was believed that the position of the carpals and tarsals would make it unlikely for damage to occur during the grease and marrow processing of the long bones. If the carpals and tarsals were intentionally fragmented they would have significant surface modification as an indication.

The limbs used in Marean's study consisted of the metapodials with adjacent phalanges and carpals and tarsals from adult sheep. The metacarpals and metatarsals

were then broken by hammerstone and anvil to duplicate marrow processing. There were no carpals or tarsals broken incidental to the hammerstone blows on the metapodials. There were no marks visible on the compact bones as well. The thick sheath of ligaments, tendons and retinaculii were assumed to have cushioned the compact bones from impact damage (Marean 1991:681). When attempts were made to intentionally fracture a compact bone the impact was obvious on the surface of the bone.

The carpals and tarsals were then offered to hyaenas to determine if the breakage patterns could have been possibly caused by carnivore damage. Despite numerous different scenarios most of the carpals remained complete, and were more likely to be swallowed whole, removing them from the assemblage instead of fracturing them (Marean 1991:685).

In the absence of either processing or carnivore damage causing the fractures of compact bones Marean assumed that the damage was post-depositional. The fractures were occurring at the point when the bone had leached out most of its mineral content but had not yet fossilized. In this fragile state sediment weight alone could have created the fractures.

The points made were extremely relevant to the Sanderson site assemblage. The protective layer of tissue around the compact bones would have protected them from anything but a deliberate, concerted effort to fracture them. If the fractures are intentional then there should be ample evidence of impact on the bone due to the difficulty in breaking them. The Sanderson site exhibited some cutmarks on the carpals and tarsals and a few chopmarks on the larger tarsals but most of them show no sign of impact damage. The effects of carnivores would be minimal on these bones as they were usually

ignored due to their solid nature and low utility. Those bones that were affected were often swallowed whole. The Sanderson site does not exhibit a bone destruction profile that matches most wolf kills, and the incidence of carnivore chewing for the entire assemblage is low. The post-depositional damage that Marean described was not a factor at the Sanderson site. The weathering profiles of the bones indicate very little cracking or damage was caused by open air exposure, and the bones were not leached out and fragile. Based on these observations another factor must be responsible for the destruction of the carpals and tarsals at the Sanderson site.

The experiments of Bonnichsen (1979) looked at the fracture properties of both fresh and mineralized bone to determine if their breakage patterns differed. Mineralized bone is bone whose structure has undergone mineral replacement of organic structures. The experiment used fresh and mineralized bovine and equine bone. The experiment found that fresh bone exhibited spiral fracture with angled edges of fracture, whereas the mineralized bone tended to exhibit transverse fractures with right angles on the edges.

The results of this experiment indicate that fresh bone breaks in a very characteristic way. In order for this breakage pattern to be altered something within the structure of the bone must change. In the case of Bonnichsen's experiment it was the loss of the elastic collagen in the bone and its replacement by ground minerals. In order for the transverse fractures with right angle edges to have occurred at the Sanderson site something must have changed the structural properties of the bone.

8.3 Ethnographic evidence

8.3.1 Grease Processing

In order to assess the breakage of the bone it is important to look not only at the physical state of the bone but also at the possible cultural behaviour that may have caused it. There are number of first hand accounts of bone breaking activities from modern ethnographic field work. Zierhut (1967) recorded the procedure for the processing of bones for marrow and grease among the modern Calling Lake Cree. In his account the meat was initially stripped off the limb and then the bone was placed near a fire briefly, but not enough to burn it. The bone was then split at the mid-shaft by a blunt object, in this case an axe but in the past a hand-held hammerstone was used (Zierhut 1967:35). The ends of the long bones were then further fragmented and placed in a container of boiling water to remove the grease. At the end of the process the only bones which were not observed to be broken were the carpals, tarsals, and phalanges.

Binford (1978) studied the bone processing activities of the Nunamiut in both the winter and the summer. He found that the carpals and tarsals were occasionally processed for grease if there was a lack of other more grease-rich elements. In such a situation the articular ends of long bones and all the carpals and tarsals were placed in a skin and hammered. An inventory of the bones after the grease had been rendered out indicated that the larger talus and calcaneous had been fractured into several pieces but the other carpals and tarsals remained complete (Binford 1978:table 4.8).

The approach to grease and marrow processing of the Calling Lake Cree would not have reproduced any of the patterns seen at the Sanderson site. The breakage of the bones at the mid-shaft and the crushing of the articular ends did not affect any of the

compact bones adjacent to them. On the other hand, processing activities like those of the Nunamiut could have caused some of this breakage. The use of carpals and tarsals during times of nutritional stress could have resulted in their fracture during processing. Despite this there is still a lack of any good evidence of impact on the compact bones from the Sanderson site and this would still not explain the dry bone fracture seen in the bone.

8.3.2 Winter butchery

One description of a winter cache of meat comes from a Hidatsa account of hunting and butchering practices (Wilson 1924:251). In this account the bison was first skinned almost to the hoof and then the ends of the four feet up to the joints were cut off and thrown away. The body was then segmented with the skinned head, neck and the backbone being discarded. A hole was then dug in the snow and the remaining articulated limbs were placed into the hole and covered with a skin (Wilson 1924:251). A flag was attached to a pole and placed on the cache to scare away the numerous wolves, coyotes and swift foxes which would often surround the kill.

The same account also mentions the scavenging of bison bones during the winter from an earlier kill as "they were fresh and had not spoiled in the cold weather"(Ibid 1924:301). The bones were collected from the kill site and then processed for marrow by pounding them with a small ax. Winter was obviously a season when scarcity of resources could become a problem, but the preservation by the cold weather provided opportunities for long term storage and scavenging of food.

Binford (1978) observed similar meat caching activity among the modern Nunamiut. He noted the following butchering units from frozen caribou meat caches: the

whole legs, the head, severed at the atlas, the neck with two thoracic vertebrae and attached short ribs, and the complete spine along with the sacrum and pelvis. When these caches were later opened and the meat removed the portions were segmented further for ease of transport and storage. The lower parts of the legs were removed by chopping through the distal articular end of the tibia of the rear leg and distal articular end of the radius in the front leg. A less frequent method involved smashing through the proximal metopodials where there was little muscle tissue to sheath the bone (ibid 1981:145). The "relatively useless lower legs" were then discarded (ibid 1978:58). This was not always done; if there was not much meat to be transported, the legs may have been transported whole. The vertebrae were chopped into three separate sections for ease of packing and transportation.

There are also accounts of ice forming in the caches despite careful site selection and cache construction by the hunter. In this situation portions of the caribou were frozen into the ground. In the account given, the lower rib section, neck and thoracic vertebrae were so embedded in ice that they had to be abandoned (Binford 1978:61).

These caches usually represented animals which were not completely butchered at the time of the initial kill. The level of butchering at the time of the initial kill is dependent on time left before sunset, whether or not the animal is to be consumed immediately or cached, current meat supplies, transportation considerations, and the intended use of the animal (Binford 1978:60). Once the animal goes into the cache and becomes frozen further butchering becomes much more difficult so it is in the best interest of the hunter to make sure it is segmented for later butchery and transportation. The caches were created to provide a meat source in the later winter and spring for the

hunter and as a source of dog food during the winter. Most of the unbutchered animals that were in the caches were broken up for dog food as trying to butcher them into the portions preferred by the Nunamiut was very difficult in their frozen state.

8.4 Archaeological evidence

Despite growing literature on the existence of winter bison hunting on the Northern Plains there has been little written about the implications of this on butchery patterns. Most butchery described in the ethnographic literature depicts warm weather patterns. These are based on late summer or early fall kills where the meat was stripped off the bison before it spoiled and dried to create a winter stock of meat (Frison 1982b:194). This stock of dried meat was supplemented by supplies of pemmican which provided the necessary fat needed to digest the meat (Todd 1991:229).

Most research on winter butchery has focused on Paleoindian subsistence patterns. The Late Prehistoric models involve the heavy processing of bone for the recovery of bone grease during the early fall. This pattern does not show up in Paleoindian sites as the season of the kill was usually much later in the season, often in the winter. The timing of these kills is thought to be part of a strategy to freeze meat in large butchered units through the winter. This strategy was meant to provide meat throughout the winter although the timing of the kill would have resulted in much of the meat being deficient in fat (Frison 1982b:201). Frison (1982b) believed the evidence for this kind of strategy could be observed at the Horner and the Carter-Kerr/ McKee sites. At these sites there were a large number of articulated limbs found with more heavily processed limbs. The unprocessed limbs were seen as the complete limbs that spoiled in the meat cache in the warmer weather of spring and were abandoned at the site. These unprocessed limbs were

also considered to have been accidentally frozen into the caches, making their recovery and processing impossible. Todd (1991) believes that if this were true there should be more evidence of frozen bone butchery but never defines how this would be visible in the archaeological record.

Paleoindian subsistence strategies are not directly relevant to the Later Prehistoric Period, but there are a number of similarities. The Sanderson site also had a number of articulated limbs found among a heavily processed assemblage. There was even an articulated spine with ribs attached in Block 7 east. Warm weather spoilage of a meat cache, or loss of the material when it became encased in ice, may provide reasonable explanations for these anomalies.

8.5 Fresh Bone Fractures

The forces that fracture bone have been most extensively studied in living animals. These patterns of breakage are related to bone as a living structure rather than the dead material that is often processed at archaeological sites. Despite this, the information from these studies is still relevant for two reasons. One, if bone is processed from a freshly killed animal it still fractures as if it were living. Two, some of the unusual fractures seen at the Sanderson site have shown up in the case studies of living animals.

8.5.1 Bovine

The unusual types of fractures that occur in the Sanderson site are not likely the result of the shaft of a fresh bone being broken open with a transverse blow. Studies on the metapodials of live animals seem to indicate that a mid-shaft transverse fracture will send the force through the bone, snapping the shaft instead of directing it proximally and

distally along the shaft and into the carpals or tarsals (Rao et al 1983:763). Unfortunately most of the literature on carpal and tarsal fracture is from horses, most likely because they endure more injuries, and a lame bovine is most likely to be put down rather than allowed to heal, especially in the case of beef cattle. Therefore most of the discussion on fractures of fresh bone will deal with an equine sample.

8.5.2 Equine

8.5.2.1 Tarsals

In terms of equine fracture of the tarsals they are most likely to occur from chronic stress concentration on the third or central tarsal bones (Meagher and Mackey 1990:108). These are usually in the form of slab fractures, a fracture extending to both articular surfaces. Most of the fractures of the talus are fragments fractured off the trochlear ridges but occasionally they are fragments off other sites or crushing type fractures that have resulted in multiple fragments. Fractures may also involve the sustentaculum tali of the calcaneus, the second and fourth tarsal bones or the head of the second or fourth metatarsal bones (Meagher and Mackey 1990:108). Only one case cited in Meagher and Mackey involved the sagittal fracture of the talus. This resulted in a lameness in the animal which became apparent when it trotted and was most likely a race injury.

The causes of these fracture seem related to the structure of the bones. The intermediate ridge of the distal tibia fits between the trochlear ridges of the talus in a fashion similar to the way a standard screw driver fits into the groove in a screw head. This suggests that if the distal limb including the talus were fixed and a rotational force were exerted on the tibia, the type of fracture seen in this case would result. This is similar to fractures of the first phalanx which have been referred to as "screw-driver

fractures" because of the anatomical relationship between the sagittal ridge of the distal metacarpals or metatarsals and the intermediate groove of the proximal first phalanx (Meagher and Mackey 1990:111). This kind of longitudinal fracture through the phalanges and slab fractures through the tarsals match some of the fracture patterns found at the Sanderson site.

8.5.2.2 Carpals

Another common site of fracture is the third carpal bone, analogous to the fused second and third of the bison. In some studies nearly 50 % of horses with carpal fractures had involvement of the third carpal bone (Richardson 1990:258). Slab fractures seem to be the result of shear failure along a plane of transition between very stiff and more compliant bone (Richardson 1990:259).

8.5.2.3 Metacarpal

Stress fractures in the metacarpal, which may be incomplete or complete, longitudinal or otherwise, are caused by repeated biomechanical stress, these stresses occur during overuse or abnormal use such as changes in gait. In humans, a change in natural gait because of concurrent osteoarthritis or acute fractures has been reported to lead to the development of stress fractures (Specht & Colahan 1990:36).

8.5.3 Summary of Fresh Bone Fracture

Had any of these fractures shown up in an archaeological assemblage they would have been difficult to explain within the context of recognized subsistence strategies. A natural solution, such as the limbs fracturing while the animal lived, is also unlikely. Although the resulting lameness in the animal would have made it an easy target for human predation by humans, there is no evidence of any reactive bone around any of the

fractures at the site. There is no evidence of use of a jump or drop which could have broken the animals limbs during the kill. What these studies can tell us is that sustained loading on bone can create some of the fracture patterns seen at the Sanderson site. Most of the forces which lead to the failure of the bone are compressive and torsional. Torsional force is an interesting idea but it seems unlikely that a human would be able to manually apply a force strong enough for these patterns to occur. Imagine the torque that the body of a 250 kilogram animal would need to apply in order to break its own leg! Compression is a real possibility if the bone were subjected to an impact. Unfortunately the compression produced by an impact can often create a much different situation than the long, static loading that can lead to the failure of a bone. It would also be essential that the compressive force were applied in the same direction, parallel to the direction of the limb. Most of the butchery patterns described in the previous section described transverse blows directed at the bones.

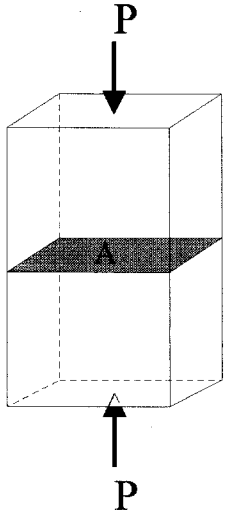
8.6 Stress and Stain

In order to discuss the nature of bone fracture it is necessary to look at the physical nature of bone and the biomechanics behind its fracture behavior. First it is necessary to discuss the basic physical forces that affect bone. Primarily there are two kinds of forces working on living bone, normal stress and shear stress (Carter & Spengler 1982:308). Normal stress (σ) is defined by the force per unit area (P) acting on a cross section at a particular point in the material (A) (Figure 8.1). The force acts perpendicular to the defined plane and is defined by the equation:

$$(Stress)\sigma = \frac{P}{A}$$

Stress can be either compressive or tensive. It does not measure the direction of the force but only how hard the atoms of material are being pulled apart or crushed together (Gordon 1988:25).

Figure 8.1 Graphic illustration of stress (σ)



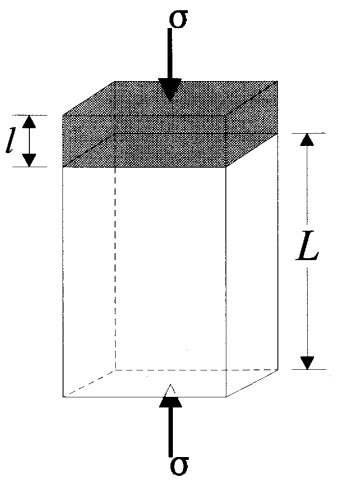
Stress measures how much force is being applied to a material, strain is a measure of the distance that the atoms in a solid are pushed or pulled. It describes the effects of the stress applied on a material and is expressed as a ratio of the change in the length of material (δL or l) to the original length (L) (Figure 8.2). For example, if a bone is compressed under stress it would be subjected to strain (ϵ) based on the equation:

$$(Strain)\ \epsilon = \frac{l}{L}$$

Strain is a ratio and therefore has no units. It is usually defined as a percentage and most materials are below one percent. This is a result of the low elasticity of most material,

although some elastic materials such as rubber can extend 800 percent while some biological materials can stretch even further (Gordon 1988:29).

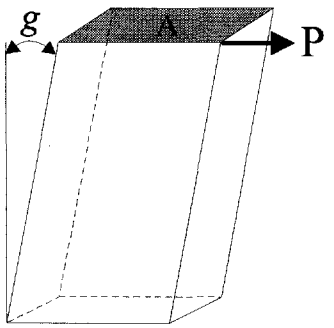
Figure 8.2 Graphic illustration of strain



Shear strain is a measure of the force per unit area acting parallel to a given plane (Carter & Spengler 1982:307). It is a measure of a materials resistance to sliding when a force, or shear stress, is applied. Unlike normal strain, shear strain measures the angle (*g*) through which the material is distorted in relation to the area of a plane (A) by the shear stress (P) (Figure 8.3).

Having only two forces working on the bone is, of course, a simplification. The bones of the skeletal system are exposed to a complex pattern of forces. This results in a bone of equally complex geometry which makes defining its exact behavior very difficult. Difficult as it may be there are certain constraints of behavior that can be expected of bone.

Figure 8.3 Graphic illustration of shear strain



8.7 Material Properties of Bone Tissue

The level of anatomical description possible for bone tissue is formidable. It is a complex material that has different structural properties depending on whether it is viewed at a macroscopic or microscopic level. Only a brief description of bone structure will discussed as the actual behaviour under external forces is more important in considering fracture patterns.

The two basic building blocks of bone are collagen and hydroxyapatite. Collagen is an elastic component that has excellent tensile properties but is not designed to handle compressive loads. In order to stiffen the strands of collagen thin fibers of hydroxyapatite [$Ca_5(PO_4)_3(OH)$] are added to the collagen during the growth and development of the bone. When the animal reaches full maturity the hydroxyapatite content reaches about 67 percent (Gordon 1988:175).

The structure of the bone is as important in determining its fracture behaviour as molecular makeup. There are two types of bone tissue, cortical and cancellous. The

difference between the two is basically arbitrary as their molecular structure is almost identical. Cancellous bone is defined as having high porosity while cortical has a low porosity (Carter & Spengler 1982:312).

Cortical bone is the dense layer of bone that tends to be thickest towards the middle of the shaft of long bones. It tends to thin out towards the extremities and then becomes dense and smooth on the articular ends (Sisson & Grossman 1963:21). Cancellous bone forms the bulk of the short bones and of the extremities of the long bones. Although concentrated in the ends of the long bones cancellous bone also extends into the shaft of the long bone (Sisson & Grossman 1963:21).

8.7.1 Young's Modulus

In order to understand bone as a material there are a few basic physical principles which have been defined to describe the behavior of materials under external forces. The only way a solid can resist an external force is by changing its shape. This means that under tension the material will stretch, and under compression the material will contract. Young's modulus is one method of measuring the behaviour of a material under conditions of tension. It is a comparison between the size of the imposed stress on a material and the size of the resulting strain:

$$Young'sModulus(E) = \frac{Stress(\sigma)}{Strain(\in)}$$

The number given for E is the amount of stress that would be required to double the length of the specimen (Gordon 1988:31). It basically measures the elasticity of a material although it is important to realize that not all materials stretch in the same way (Table 8.1). In most materials the strain increases linearly with the increased stress.

Table 8.1. Young's Modulus for selected materials. (From Gordon 1988:31)

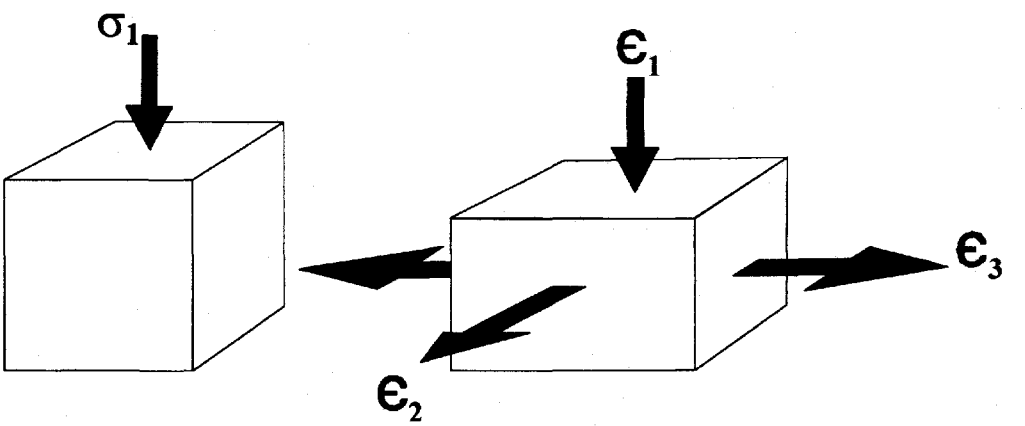
Solid	E in p.s.i x10^6
Soft biological tissues	0.00003
Rubber	0.001
Wood	1.6
Cement	2.5
Bone	**3.0**
Glass	10.0
Steel	30.0

Biological materials such as bone do not behave in a totally linear manner. They tend to exhibit what is called a "J curve" where a small stress will result in a large strain but as the stress increases the amount of strain decreases. This is part of the toughness that is built into many soft tissues.

8.7.2 Poisson's Ratio

Poisson recognized that a material was affected in three directions when under stress, not simply one as Young's Modulus measured. When an object is compressed in one plane it will be under tension in two others (Gordon 1988:32) (Figure 8.4).

Figure 8.4 Example of the forces acting on an object under compression



The strain, ϵ_1, is a function of Young's Modulus as it measures the strain along one axis when subjected to the stress σ_1. Poisson showed that this stress will also cause strains ϵ_2 and ϵ_3 along the two axes normal to the stress axis. These secondary strains will relate to the primary stress and strain (ϵ_1) based on the equation:

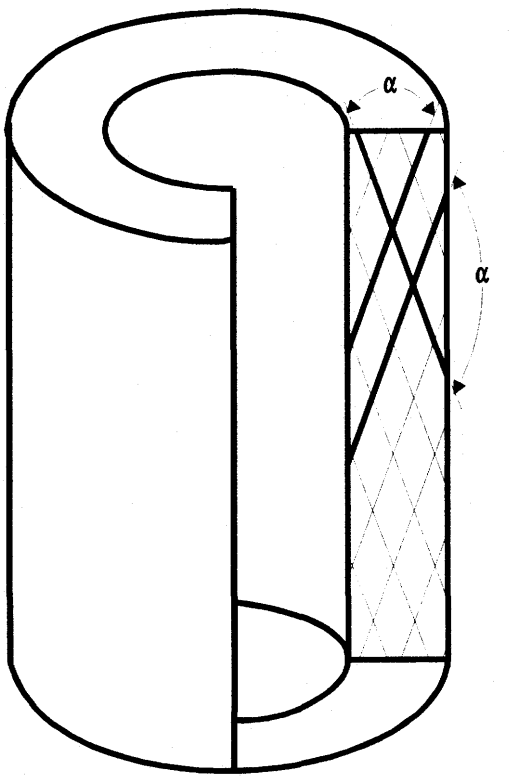
$$\epsilon_2 = \epsilon_3 = -\nu\, \epsilon_1 = -\nu \frac{\sigma_1}{E}$$

The proportionality constant (ν) is known as Poisson's ratio. If the primary stress and strain are compressive, the secondary strains will be tensile and visa versa. If the material is homogeneous or isotrophic it will have the same properties regardless of the direction of the force applied. Poisson's ratio cannot be greater than 0.5 for isotrophic materials. A nearly fluid material or gel would have a Poisson's ratio close to 0.5. To visualize this the box in figure 8.4 would have translated all the force applied to the top of the box into expansion of the sides of the box. This way the material from which the box is constructed is not damaged by the stress applied to it.

Biological materials such as bone have a very complicated molecular morphology that can make them behave quite differently under different kinds of stress. Many of them are anisotrophic or having different elastic properties in different directions. In figure 8.5 the cortical bone in a section of long bone shaft illustrates how anisotrophy can affect its physical behaviour. The smaller angle (α) for the longitudinal dimension of the bone gives it a higher Poisson's ratio. This means cortical bone is much stronger and stiffer in the longitudinal direction, the direction of osteon orientation, than in the transverse direction. Conversely the transverse dimension of the bone has a larger angle of anisotrophy and a lower Poisson's ratio. Forces applied in a perpendicular direction to

the osteons tend to shear across this plane, causing the bone to fail in a more brittle manner, with little elastic deformation (Carter & Spengler 1982:313). As a result of this structural organization the long bone can take much more compression in its longitudinal direction than its transverse. The bone material will begin to take direct damage and fail transversely long before a similar force would affect it longitudinally.

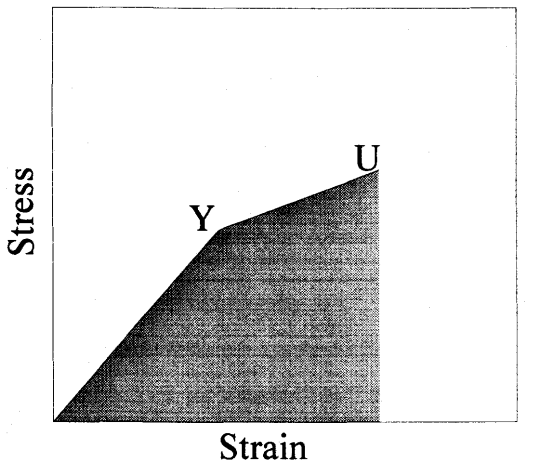
Figure 8.5 Anisotrophic characteristics of a long bone shaft.



8.7.3 Bone failure

In figures 8.2 and 8.3 the small sample cubes of bone deform under the forces exerted on them. This is due to the elastic nature of bone. When the force is removed the bone will return to its original form. There is a point however, when the force applied to the bone will overcome the structure of the bone itself (Figure 8.6). This point is referred to as the yield point (Y), when physical damage begins to occur in the bone and the

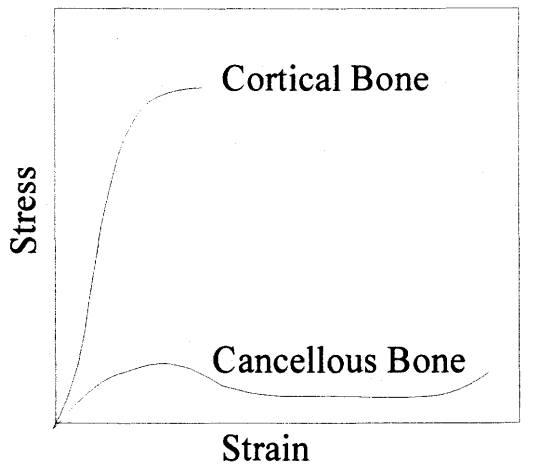
Figure 8.6 Illustration of bone yield point (Y) and ultimate point (U). Shaded gray area represents a sum of the energy required for the failure of the bone.



bone's elasticity no longer protects it. If the force continues it will reach the ultimate point (U) at which the bone fails and fractures (Carter & Spengler 1982:308).

The failure behaviour of bone is also dependent on its structural make-up. The structure of cancellous bone results in markedly different stress-strain behavior than cortical bone (Figure 8.7). Cancellous bone has a compressive behavior similar to porous

Figure 8.7 Comparison of the failure behaviour different bone structures



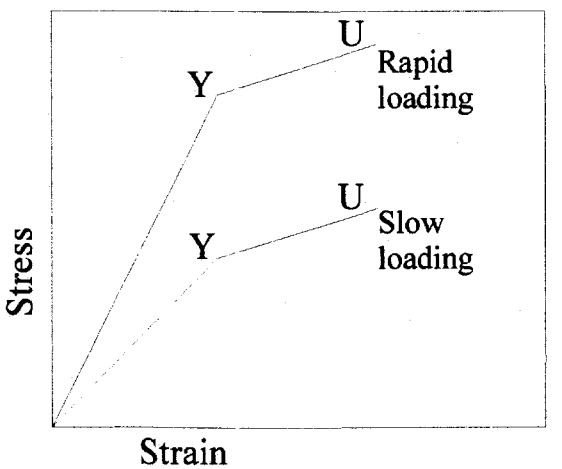
engineering materials which are used to absorb energy upon impact. The cancellous bone exhibits an initial elastic behavior which is followed quickly by a yield when the

trabeculae within its structure begin to fracture (Carter & Spengler 1982:317). The behavior of the fracture is not as catastrophic as in cortical bone and tends to follow a long plateau during which progressively more and more trabeculae fracture.

8.7.4 Viscoelasticity

The behaviour of bone is not only dependent on the direction of force applied to it but the rate at which the bone tissue is loaded or deformed (Carter & Spengler 1982:313). Bone tissue that is subjected very rapidly to force will have a greater elasticity and ultimate moment. This will make it capable of absorbing considerably more energy than

Figure 8.8 Comparison of the failure behaviour at different loading speeds.



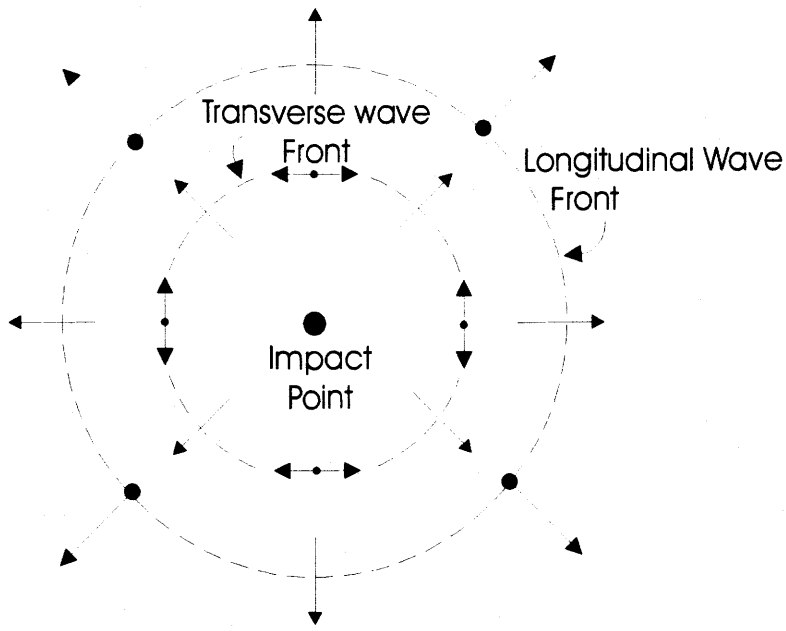
bone loaded very slowly. Bone is then viscoelastic, meaning that its stress and strain characteristics are dependent upon the applied strain rate.

8.7.5 Mechanics of impact fracture

Much of the data on bone fracture involves fracture under static loading; that is, the application of constant force on the bone resulting in its eventual failure. The information from these studies can be misleading when trying to apply this data to impulsive loading situations. Impulsive loading is created by impact or explosion and

produces deformations and stresses that are not immediately transmitted to all parts of a body (Rinehart 1960:3). It creates a much different situation than material failure under static loads where the entire body is affected simultaneously. An impact on a bone creates two types of stress pulse which travel through the body of the object as compressive waves (Figure 8.9). The first type is called the longitudinal wave or the Primary (P) wave. In this kind of pulse the particle motion is parallel to the direction of propagation of the pulse. The other type of pulse is the transverse wave or secondary (S) wave. In a transverse pulse particle motion is normal to the direction of the propagation of the wave (Ibid:3). The longitudinal wave has approximately twice the propagation velocity of the transverse wave and accordingly causes most of the destruction in the material as it reaches the edges of the body long before the transverse wave. Many

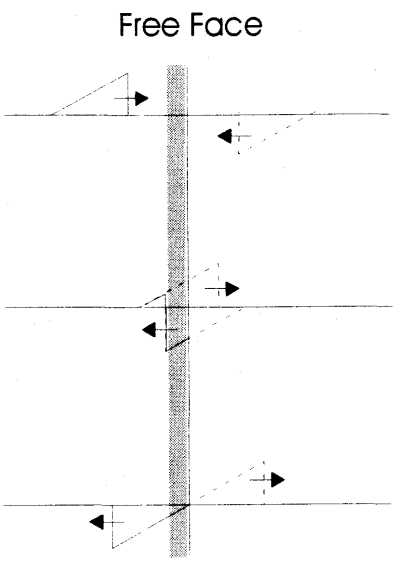
Figure 8.9 Two types of stress pulses created by an impulsive load. (After Rinehart 1960:Figure 2.01)



materials are designed to fail in compression at the origin of the impact. This lessens the intensity of the wave created and helps to prevent the failure of the rest of the body unless the shape of the body itself creates stress concentrations elsewhere.

Any wave created by an impact will be reflected back when it reaches a free surface of the material it is traveling through (Figure 8.10). This means that a compressive wave will move through an object until it reaches the border of that material. It will then create a wave reflected in tension of equal force that will travel back towards the origin of the wave with an equal and opposite force. This will have the effect of canceling the compressive force in the material and returning it to a stress free state. If the surface that the wave encounters is perpendicular to the wave front then the wave reflects perfectly back on itself. If the surface is oblique to the direction of the wave the situation becomes much more complicated. When the wave is reflected back onto itself as in figure 8.10 the tensile wave does not reach its full strength until it completely cancels the initial compressive wave. In the third stage of figure 8.10 the tensile wave is

Figure 8.10. Dynamics of wave reflection of a saw toothed wave at a free face (After Rinehart 1960:Figure 2.04)



at full strength and it is already well into the body of the material. If the material is going to fail in tension it will happen at this point, flaking off the surface of the material and creating a spall. In a perfectly incoherent material, one that has almost no strength in tension the material will flake apart completely.

If a material is made up of laminations it will contain a certain number of layers and an equal number of interfaces. When a wave encounters an interface it will continue on to the next layer but it will also reflect a wave back, the same way it would if it encountered a free surface. If the next layer has different material properties then the wave can often have its form altered and subsequently its reflected wave will alter its form as well (Rinehart 1960:69). If a gap exists between the two layers the situation is slightly more complex. If the gap is filled with air then it acts as a dampener since the compressive wave expends energy pushing the two layers together in order to transmit to the next layer. If the gap is filled with material it acts as a small lamination itself often dampening the strength of the wave. If this material has a low tensile strength such as grease it acts to trap the wave in the second layer as it will fail when the tensive wave is reflected back from the second layer. This situation will limit the amount of reflected wave activity in the laminated structure, limiting the destructive potential of the tensile waves.

This is a very simple explanation of a very complex physical phenomenon, but there a number of implications for the breakage of bone. One, bone is a material that is designed to resist compression rather than tension. This is part of the physical nature of bone. When a compressive wave traveling through the bone reaches a free surface the compressive wave becomes reflected and the tensile wave can destroy the bone by

creating a spall off the surface of the free face. Two, when there is a gap between the free surfaces of two materials and it is filled with a compound, it has the effect of dampening the compressive wave and reflecting the tensile wave. The fluid-filled gaps between cortical bone laminations, and the synovial fluid that helps form the gaps between the joint surfaces all act as dampeners to impulsive waves moving through the bone. If the agents that fill these gaps had their physical nature changed through freezing much of the wave dampening features of bone would be lost, making it much more brittle and susceptible to damage. Three, when the shock wave does create a fracture in the bone it is affected by a multitude of microcracks throughout the bone. These act to stop crack propagation from reaching a critical length. The critical Griffith crack length for bone is around three centimeters. When this is reached catastrophic failure of the bone often occurs. The behaviour of this system of microcracks is called the Cook-Gordon effect. It is a system designed to allow localized failure of planes of weakness but not total destruction of the bone (Gordon 1988:100). It is similar to the effects on wave propagation caused by laminations within physical structures.

8.7.6 Summary

The biomechanical nature of bone has numerous implications for understanding the Sanderson site assemblage. The fact that the bone is all highly comminuted means it was likely subjected to very rapid loading of a high rate. This would require something like a maul or sledge. The fact that the cortical bone is so shattered is of no surprise. The bone was likely struck transversly to its length taking advantage of the low elasticity and low ultimate point of the bone. This would fit in well with the processing of bone for marrow extraction and would not be affected by temperature. Cold temperature would

affect cortical bone by freezing the collagen and thereby lowering its ultimate point by reducing the bone elasticity. The loss of elasticity would lower the Poisson's ratio of the bone, it would no longer be able to deform to compensate for the stress load. This would result in an increase of propagation velocity of both longitudinal and transverse waves created by the impact on the bone and more widespread destruction on the bone.

Another implication is for the cancellous bone. The structure of this bone is such that it will not fracture easily. Instead its lattice-like structure will slowly crush under force. Contained within this trabecular structure is the grease which was sought after as a source of fat by native people. Attempting to break up the cancellous bone while in its fresh state would be like trying to smash apart a sponge full of water. Much of the grease would be lost. Experiments done during the summer when the grease was in a more liquid state resulted in the conclusion that "bone degreasing is a tedious activity requiring significant expenditures of time, materials and labour for what turns out to be a very meager reward" (Wright & Brink 1986:138). In their experiment much of the grease came out of the bone and stuck to the anvil stone, hammerstone and tool user. If, on the other hand, the bone was frozen solid the shock-absorbing nature of the trabeculae and the fluid between them would be lessened, due to a loss in elasticity, allowing a fracture to travel through the bone with more ease.

8.8 Experimental method

The experiment performed was designed to provide information about two primary objectives: One was to determine whether or not the breakage of long bones in their frozen state would affect adjacent compact bone. Freezing should limit the wave dampening attributes of the joint, possibly allowing compressive forces to travel through

the carpals and tarsals adjacent to the impacted long bone. The second objective was to assess the effects of the frozen state of the bone on the breakage patterns. There were two controls in the experiment. First, the use of both fresh and frozen limbs allowed identical treatment of the limbs to ensure that any fracture patterns were the result of the physical state of the limb and not the method used to break them. Second, the fresh limbs had been frozen for the same period of time as the frozen ones before they were thawed out. This allowed the for assessment of the desiccation effect of freezing on the bone to ensure that the breakage effects seen were the result of the frozen state of the bone and not the storage method used for them.

Eight bovine limbs, four forelimbs and four hindlimbs were used for the experiment. They were provided by the Pathology Department of the College of Veterinary Medicine at the University of Saskatchewan. They were from necropsied domestic cattle and were sawn off the carcass at the mid-shaft of both the radius-ulna and the tibia. The limbs were taken intact to the Department of Anthropology and Archaeology at the University of Saskatchewan and stored in a freezer for 14 days. At this point four limbs, two forelimbs and two hindlimbs, were removed from the freezer and allowed to thaw over a 48 hour period previous to the experiment.

The experiment was recorded on 35 mm film and videotape for the purposes of documentation. The soft tissue on the limbs eliminated the possibility of documenting the fracture patterns occurring as the limbs were struck.

8.8.1 The Experiment

The limbs were taken out to Wanuskewin Heritage Park during the winter for the actual experiment. The air temperature was well below 0°C so there was no chance of

the frozen limbs experiencing any thaw during the course of the experiment. Initial attempts at using an over the shoulder swing to break the limbs worked with a fresh limb but proved impossible with the frozen sample. The blunt end of an ax was then used to break apart the remaining fresh and frozen limbs, the blows were delivered while the limbs lay flat on the frozen ground. The direction and placement of the blows consisted of lateral and medial blows on the distal radius and proximal metacarpal of the forelimb and distal tibia and proximal metatarsal of the hind limb. The number of blows varied between three and eight as the limb was struck until it was broken.

8.8.2 Experimental results

The limbs were processed at the College of Veterinary Medicine. They were stripped of most of their tissue and then boiled for 14 hours to help in the removal of adhering tissue. The results of the study are summarized in table 8.2. There were a number of interesting observations when the bones were examined. The kind of breakage varied between fresh and frozen bone. The fresh limbs exhibited classic spiral fractures around the length of the diaphysis while the frozen limbs exhibited mainly transverse fractures through their shafts. The angle of the fracture in the fresh bones tended to be sharp, at an acute or obtuse angle while the frozen bones mainly exhibited fractures that were perpendicular to the surface of the bone shaft. In the fresh bones the fracture lines from the medial and lateral impacts on the bone traveled into the ends of the long bones and were arrested by the cancellous bone. In the frozen bones the cancellous tissue did not absorb the force as well, and the fracture often travelled right through it and into the articular surface of the bone. The impact scars were also different. In the fresh bones it was usually easy to spot the cone of percussion at the initial impact

Table 8.2 Summary of experimental data

Experimental subject	Bone element	Texture of fracture surface	Angle of fracture	No. of fragments
Frozen forelimb 1	radius	N/A	N/A	1
	carpals	N/A	N/A	1
	metacarpal	rough	perpendicular	90
	total			92
Frozen forelimb 2	radius	N/A	N/A	1
	carpals	N/A	N/A	1
	metacarpal	smooth to rough	perpendicular	51
	total			53
Frozen hindlimb 1	tibia	smooth to rough	perpendicular	7
	Astragalus	rough	perpendicular	2
	other tarsals	N/A	N/A	1
	metatarsal	smooth to rough	perpendicular	19
	unid. bone frags			86
	total			115
Frozen hindlimb 2	tibia	smooth to rough	perpendicular, acute	19
	tarsals	N/A	N/A	1
	metatarsal	rough	perpendicular	11
	unid. bone frags			26
	total			57
Fresh forelimb 1	radius	N/A	N/A	1
	carpals	N/A	N/A	1
	metacarpal	smooth to rough	acute	6
	total			8
Fresh forelimb 2	not broken			
Fresh hindlimb 1	tibia	smooth	acute	8
	tarsals	N/A	N/A	1
	metatarsal	smooth	acute	6
	unid. bone frags			31
	total			46
Fresh hindlimb 2	tibia	smooth to rough	acute, obtuse	6
	tarsals	N/A	N/A	1
	metatarsal	smooth to rough	acute	8
	total			15

and the radiating lines from it. The impact point on the frozen bones could usually be identified only by the increased level of fragmentation in that region of the bone. In some cases a plug of bone had been knocked out but its shape was irregular and the edges perpendicular. There also seemed to be a higher level of fragmentation among the frozen bones. This is likely due to the increased amount of force required to fracture the bone and its brittle nature due to its changed biomechanical nature.

8.8.3 Frozen limbs

In frozen forelimb one (Figure 8.11) the distal radius did not fracture. There is evidence of a compressive fracture on the distal medial surface of the bone. A single crack runs proximally and distally but the bone is intact. The fracture runs into the articular surface of the bone but there was no evidence of fracture in the carpals. The metacarpal of the limb exhibited a high level of fragmentation. The impacts on the medial and lateral surfaces of the proximal end of the bone split the proximal articular surface along the sagittal plane. There was no evidence of an impact scar on the bone although there is a concentration of fracture lines near the impact zone. The distal end of the bone where no impact occurred exhibited a single, clean transverse break with no evidence of multiple fracture lines.

Frozen forelimb two (Figure 8.12) exhibited a similar pattern as the radius was again intact. During the experiment extreme force was applied to the radii of both these limbs but it is apparent that these attempts had no effect on the bone, obviously quite resiliant in its frozen form. The carpals exhibited no signs of ancillary damage from the radius or metacarpal. The metacarpal again exhibited a high level of fracture. The medial, proximal end of the bone was essentially blown apart by the nearby impact. The

Figure 8.11 Frozen forelimb one

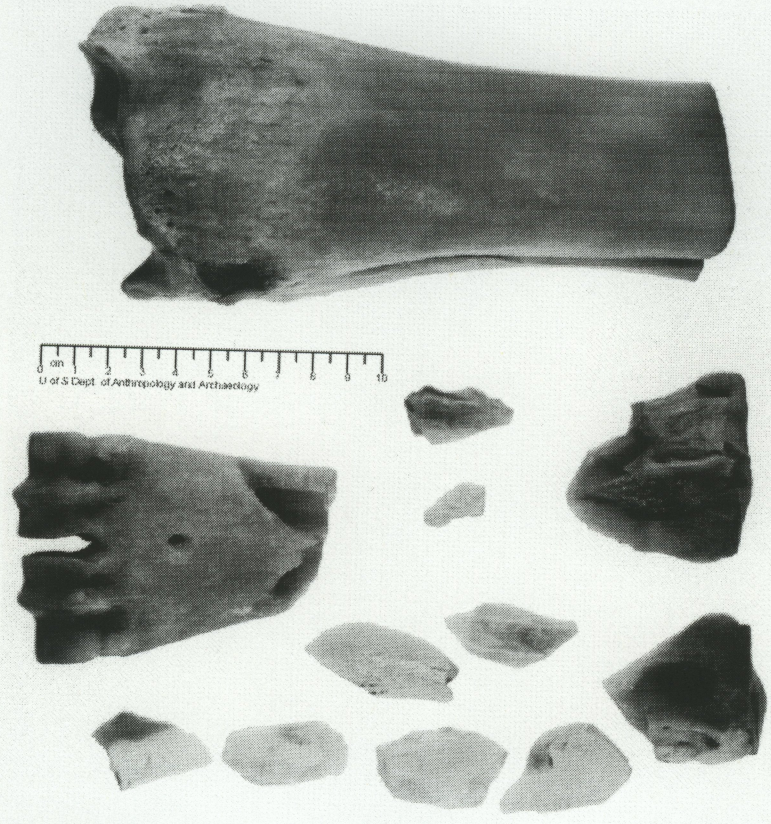


Figure 8.12 Frozen forelimb two

Figure 8.14 Fresh forelimb one

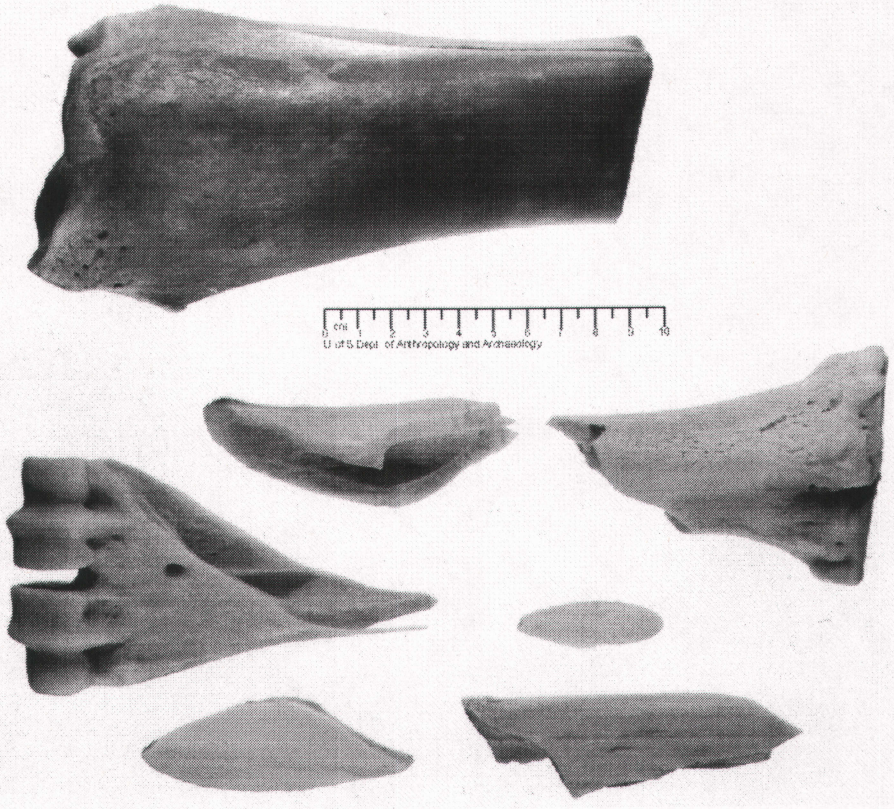
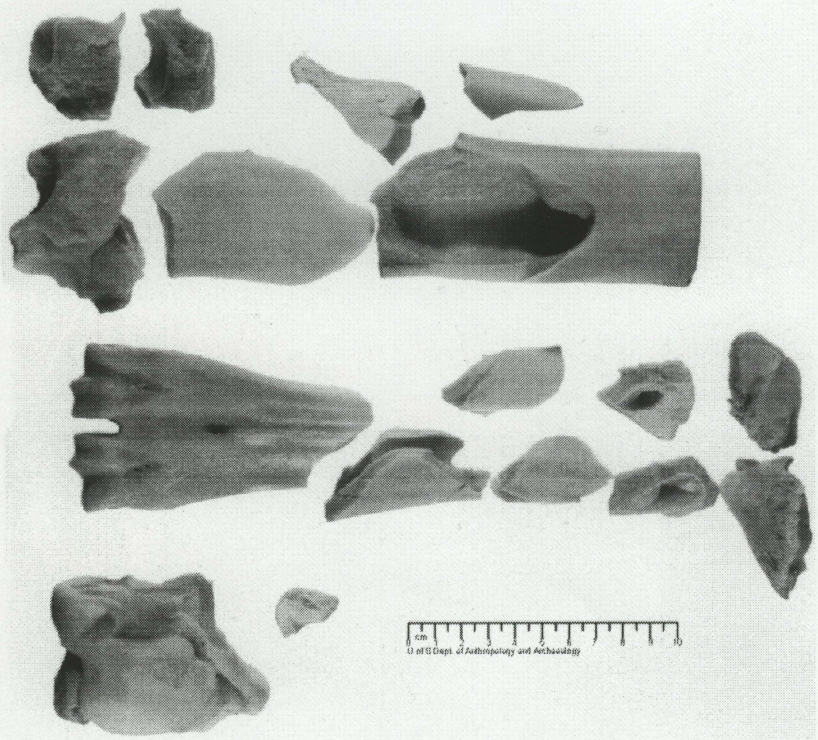


Figure 8.15 Fresh hindlimb one

impact appears to have knocked out flakes from the surface of the area surrounding the impact point but the edges of these flakes exhibited a step fracture morphology.

The experiment on frozen hindlimb one (Figure 8.13) resulted in the fracture of all the bones that were struck. The distal tibia had fractures running through the cancellous bone of the articular end. The impact points on this limb were difficult to detect as there was only a small amount of flaking on the surface near the impact point. The lateral malleolus survived despite the almost total destruction of the tibial bone surrounding it. There was only one hairline crack running proximally to distally in a transverse plane through the bone. The talus was the only tarsal to exhibit any destruction. There is a small step fracture at the medial condyle base and the medial

Figure 8.13 Frozen hindlimb one



condyle has been broken off. The damage is likely due to a misdirected blow from impacts on the distal tibia. The metatarsal of the limb was highly fragmented. The proximal end of the bone was completely fragmented from the medial and lateral blows. Like the forelimbs the impact area is composed of a cluster of hairline fractures while the distal end of the bone exhibits a single, clean transverse fracture.

The fracture patterns of frozen hindlimb two were very similar except there was no damage to the tarsals. The impact point on the lateral side of the distal tibia was visible when the bone was refitted. It appeared as a small plug of bone missing from the limb with sides that were perpendicular to the surface of the bone. The proximal end of the metatarsal was split in the sagittal plane from the medial and lateral impacts of the proximal shaft. The impacts were again visible as a small plug of bone missing with perpendicular sides.

8.8.4 Fresh Limbs

Fresh forelimb one (Figure 8.14) exhibited classic bone fracture patterns. Again the distal radius was not completely broken and it is obvious that this bone element is resiliant to destruction in both its fresh and frozen state. There was only one small depressive fracture seen on the bone. The carpals remained completely intact. The metacarpal exhibited spiral fracture around the shaft of the bone from the impact sites. The impact points were visible and the ripple effects or "hackle marks" were visible at the point of impact. Fresh forelimb two was not broken during the experiment. At the time there was enough material in order to assess the experiment, and this limb was left intact.

Fresh hindlimb one demonstrated classic bone breakage behaviour during the experiment (Figure 8.15). The tibia exhibited spiral fractures which ran around the shaft

of the bone and stopped when they hit the cancellous bone of the epiphysis. The tarsals remained intact after the experiment. The metatarsal showed a spiral fracture pattern although there was one partial transverse fracture at the distal end of the bone. The impact sites showed a concoidal scar in the bone and some flakes on the adjacent bone surface.

Fresh hindlimb two had a similar fracture pattern with spiral fractures in both the tibia and the metatarsal. The tibia had a concoidal impact scar on the bone as evidence of impact and the metatarsal had no obvious evidence of impact as the bone around the site was too fragmented.

8.9 Conclusions

This study was designed to assess the differences in fracture patterns caused by the physical state of the bone. It was necessary as there have been no previous attempts to investigate the differences between the biomechanical behaviour of butchered bone in the fresh and frozen state. It was not exhaustive, but it raised a number of implications for both the Sanderson site and butchery sites in general.

The mix of fresh and transverse fracture patterns at the Sanderson site can be explained by the differences between processing frozen and fresh limbs and bones. It is important to note that the dry bone fractures seen at the Sanderson site have a number of different possible origins. Dessication, de-mineralization and extreme weathering could all have played a part, but all of these issues were addressed and dismissed in the taphonomy assessment. There are a number of reasons that the limbs would be frozen in the first place. The amount of time to completely butcher a bison is considerable, if there were a number of them killed at one time it may not have been possible to completely

strip the carcasses with the available daylight. The Sanderson site is located on a north-facing hill slope which combined with a low sun angle and photoperiod during winter months would have led to a short period of daylight. If the labour force and time was limited, only a basic segmentation of the bison would have been possible.

If the limbs were placed in a cache over the winter they would have to be butchered in their frozen state when they were removed. If there had been little initial segmentation of the limbs due to initial time constraints it would be necessary to break the limb into portions unless it was practical to thaw out an entire limb at once. It is more likely that the limb was segmented into portions that related to certain activities. For example, the upper part of the limb would be removed if the frozen meat was being butchered while the metapodials would be segmented if marrow was sought. The location of the segmentation is difficult to assess. The experiment indicated that the easiest place to break apart a limb is the metapodials, followed by the distal tibia and distal radius. This is due to an increase in muscle, tendon and fat proximally on the limb which in the frozen state is almost impossible to penetrate. There is also the possibility that only the bones remain in a cache from an earlier meat butchery event. It is unlikely that an entire bison was processed for its meat, marrow and grease in a single day and this would have left a cache of frozen bone behind for later processing. When this bone was processed it would have exhibited a much different breakage pattern than the fresh bone. This frozen bone would exhibit transverse fracture patterns, and impact points on the bone would be very difficult to identify.

None of the slab fractures seen at the Sanderson site showed up in the experiment. Despite stress concentrations creating cracks straight through the cancellous bone of the

articular ends of many of the frozen bones no adjacent bones were fractured. It seems that the gaps between the bones in the joint still provide enough wave dampening ability to reduce the severity of the shock wave. Based on the single fractured tarsal from the experiment it would seem that they only way the compact bones could be affected is if they were directly struck. The frozen state and cancellous structure would have resulted in fractures with little or no indication of an impact point.

The bone breakage at the Sanderson site also caused problems in the assessment of the utility indices designed to predict resource usage at a site. None of these models seemed to fit the Sanderson site subsistence strategies. There could have been a number of factors biasing this but one which was obvious was the apparent lack of metapodials. Their absence from the site caused poor correlation and a lack of statistical significance in a number of the indices. Once they were removed from the analysis significantly better results were obtained. If these particular bones were physically removed from the site and taken to another processing area this would explain the difference. If they underwent frozen bone butchery they would also have disappeared from the faunal assemblage as many would have been too fragmented for identification. This was only one of the low utility bone portions which seemed to be missing from the assemblage. The distal tibia was one of the other bone portions which was under represented. If all of these were removed from the calculations then a much better correlation with the models would have occurred. It seems more than a coincidence that the bones missing from the assemblage aree those portions of the limb where disarticulation is easiest when the limb is in a frozen state.

This experiment was not designed to solve all of the problems that arise when dealing with a winter kill/ butchery site as it has opened as many questions as it has answered. It has succeeded in raising the awareness that different seasons can result in very different patterns of bone breakage during butchery. This is not a sole determiner of seasonality but it is information to keep in mind when analyzing the faunal material from any site. It affects the assessment of taphonomic factors at the site as well as the butchery patterns predicted by many utility indices. As indicated by section 7.5.4 it can be the difference between total chaos and the semblance of some kind of butchery pattern at a site.

CHAPTER 9

SUMMARY AND CONCLUSIONS

This thesis deals with the analysis of a faunal assemblage from the Sanderson site, a Mortlach Phase occupation of the Late Prehistoric Period (1750 to 170 BP). The later part of this period extends into the protohistoric (250 to 70 BP), times when the horse and European trade goods appeared on the Northern Plains. The Mortlach Phase occurred towards the end of the Late Prehistoric Period beginning about 1500 A.D. and ending with European occupation of the Plains. The focus of the study is mainly site specific although information drawn from the experimental study has implications that go well beyond this.

The Sanderson site was located in southeastern Saskatchewan along the Souris River. The salvage excavation for the Rafferty Dam reservoir opened up 211 m^2 of which block 7 west with 48 m^2 was used as a sample. The faunal material recovered could be described as being in excellent condition but highly fragmented. The site was composed of two occupation levels separated by a layer of sterile clay. Flooding by the nearby Souris River was responsible for the burial of the site. The site was used primarily for the butchery of animal resources. There were many animal species at the site but bison represented the bulk of these. The condition of the bone indicates that grease processing would have been a major activity. Bison dentition and fetal information indicated a seasonality of late fall/ early winter occupation. Other faunal material and paleobotanical information indicate an early fall occupation. Both of the occupation levels had similar indicators of seasonality. It is likely that the site was occupied in the early fall so that local resources could be exploited and when the colder weather drove the bison into the

sheltered river valley they too were hunted. Sex composition studies of the bison herd indicate that it was a mixed male and female herd. If the assemblage represent a singl kill this condition would seem to be unlikely. Conventional literature believes that bison herds were split into sex specific male bull herds and female nursery herds after the rut in summer. There is growing evidence that this was not an absolute and that environmental and subsistence factors could create mixed herds during the winter as well. It is equally possible that a series of attritional kills occurred throughout the winter of either mixed or sex specific herds.

Unusual breakage patterns in the bone, and destruction of other bones of low yield, may have been the result of seasonal butchery patterns at the site. They could not be explained within conventional predictive models for butchery behavior but when viewed from the point of winter butchery they appeared to make sense. The bone breakage experiment of this study indicated that butchering frozen limbs resulted in distinctive breakage patterns of the bone, a higher level of fragmentation and destruction of bone elements. Many of these patterns were not predicted by the utility indices used in analyzing the subsistence strategy at a site.

The Sanderson site provides a picture of the bison processing behavior of the Late Prehistoric during the winter season. It is the most detailed faunal analysis done on a Mortlach site from southern Saskatchewan and therefore furnishes a basis for comparison for any future studies in the area. The butchery patterns observed and the experiment used to replicate them provided information about the possible effects of cold weather on the formation of a faunal assemblage. This knowledge is wide ranging and could affect the analysis of faunal assemblages going back to Paleoindian times. Awareness of its

affects could aid many who are dealing with patterns of a suspected winter processing site.

APPENDIX I

FAUNAL SPECIES

Table 1. Mammalian species in the McDonald Lake Region.

Order	Family	Common Name	Scientific Name
Artiodactyla			
	Cervidae		
		Mule deer	*Odocoileus hemionus* [1]
		White-tailed Deer	*Odocoileus virginianus* [1]
		Elk	*Cervus elaphus* *
	Antilocapridae		
		Pronghorn	*Antilocapras americana* *
	Bovidae		
		Bison	*Bison bison* *
Carnivora			
	Canidae		
		Swift Fox	*Vulpes velox* *
		Red Fox	*Vulpes vulpes* [1]
		Coyote	*Canis latrans* [1]
		Wolf	*Canis lupus* *
	Ursidae		
		Black Bear	*Ursus americanus*
		Grizzly Bear	*Ursus arctos* *
	Procyonidae		
		Raccoon	*Procyon lotor* [1]
	Mustelidae		
		Ermine	*Mustela erminea*
		Long-tailed Weasel	*Mustela frenata*
		Least Weasel	*Mustela nivalis* *
		Black-footed Ferret	*Mustela nigripes* *
		Mink	*Mustela vison* [1]
		Wolverine	*Gulo gulo* *
		Badger	*Taxidea taxus*
		Striped Skunk	*Mephitis mephitis* [1]
		River Otter	*Lontra canadensis*
	Felidae		
		Mountain lion	*Felis concolor*
		Bobcat	*Lynx rufus*

APPENDIX I

Order	Family	Common Name	Scientific Name
Rodentia			
	Sciuridae		
		Least Chipmunk	*Eutamias minimus*
		Woodchuck	*Marmota monax*
		Richardson's Ground Squirrel	*Spermophilus richardsonii* [1]
		Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus* [1]
		Franklin's Ground Squirrel	*Spermophilus franklini*
		Fox Squirrel	*Sciurus niger* [1,2]
	Geomyidae		
		Northern Pocket Gopher	*Thomomys talpoides*
	Heteromyidae		
		Olive-backed mouse	*Perognathus fasciatus*
	Castoridae		
		Beaver	*Castor canadensis*
	Muridae		
		Deer Mouse	*Peromyscus maniculatus*
		Northern Grasshopper Mouse	*Onychomys leucogaster*
		Gapper's Red-backed vole	*Clethrionomys gapperi*
		Muskrat	*Ondatra zibethicus*
		Prairie Vole	*Microtus ochrogaster*
		Meadow Vole	*Microtus pennsylvanicus*
	Erethizontidae		
		Porcupine	*Erethizon dorsatum* [1]
Lagomorpha			
	Leporidae		
		Snowshoe hare	*Lepus americanus*
		White-tailed Jack Rabbit	*Lepus townsendii* [1]

* Extirpated, 1 Recorded in 1987 wildlife survey of McDonald Lake, 2 Extralimital

Table 2. Avian species of the McDonald Lake region

Order	Family	Common Name	Scientific Name
Podicipediformes			
	Podicipedidae		
		Pied-billed Grebe	*Podilymbus podiceps* [1]
		Horned Grebe	*Podiceps auritus*
		Eared Grebe	*Podiceps nigricollis* [1]
		Western Grebe	*Aechmophorus occidentalis* [1]
Pelecaniformes			
	Pelecanidae		
		American White Pelican	*Pelecanus erythrorhynchos* [1]
	Phalacrocoracidae		
		Double-crested Cormorant	*Phalacrocorax auritus* [1]
Ciconiiformes			
	Areidae		
		American Bittern	*Botaurus lentiginosus*
		Great Blue Heron	*Ardea herodias* [1]
		Black-crowned Night-Heron	*Nycticorax nycticorax* [1]
Anseriformes			
	Family Anatidae		
		Tundra Swan	*Cygnus columbianus* [1]
		Greater White-fronted Goose	*Anser albifrons*
		Snow Goose	*Anser caerulescens* [1]
		Ross's Goose	*Anser rosii* [1]
		Canada Goose	*Branta canadensis* [1]
		Green-winged Teal	*Anas crecca* [1]
		American Black Duck	*Anas rubripes* [1]
		Mallard	*Anas platyrhnchos* [1]
		Northern Pintail	*Anas acuta* [1]
		Blue-winged Teal	*Anas discors* [1]
		Northern Shoveller	*Anas clypeata* [1]
		Gadwall	*Anas strepera* [1]
		American Widgeon	*Anas americana* [1]
		Canvasback	*Aythya valisineria* [1]
		Redhead	*Aythya americana* [1]
		Lesser Scaup	*Aythya affinis* [1]

APPENDIX I

Order	Family	Common Name	Scientific Name
Anseriformes			
	Family Anatidae		
		Common merganser	*Mergus merganser* [1,2]
		Ruddy Duck	*Oxyura jamaicensis* [1]
Falconiformes			
	Cathartidae		
		Turkey Vulture	*Cathartes aura*
	Accipitridae		
		Marsh Hawk	*Circus cyaneus*
		Sharp-shinned Hawk	*Accipiter striatus*
		Swainson's Hawk	*Buteo swainsoni*
		Red-tailed Hawk	*Buteo jamaicensis*
		Ferruginous Hawk	*Buteo regalis*
	Falconidae		
		American Kestrel	*Falco sparverius*
		Merlin	*Falco columbarius*
Galliformes			
	Phasianidae		
		Greater Prairie-Chicken	*Tympanuchus cupido*
		Sharp-tailed Grouse	*Tympanuchus phasianellus*
Gruiformes			
	Rallidae		
		Sora	*Porzana carolina*
		American coot	*Fulica americana*
Strigiformes			
	Strigidae		
		Eastern Screech-Owl	*Otus asio*
		Greater Horned Owl	*Bubo virginianus*
		Burrowing Owl	*Athene cunicularia*
		Long-eared Owl	*Asio otus*
		Short-eared Owl	*Asio flammeus*
		Northern Saw-whet Owl	*Aegolius acadicus*
Passeriformes			
	Corvidae		
		Magpie	*Pica pica*
		Crow	*Corvus brachyrhynchos*

1 Recorded in 1987 wildlife survey of McDonald Lake, 2 Extralimital

Table 3. Reptilian and Amphibian species in the McDonald Lake region

Common Name	Scientific Name
Plains Spadefoot	*Scaphiopus bombifrons*
Dakota Toad	*Bufo hemiophrys*
Leopard Frog	*Rana pipiens*
Boreal Chorus Frog	*Pseudacris triseriata*
Wood Frog	*Rana sylvatica*
Painted Turtle	*Chrysemys picta*
Snapping Turtle	*Chelydra serpentina*
Plains Hognose Snake	*Heterodon nasicus*
Red-sided Garter Snake	*Thamnophis sirtalis*
Plains Garter Snake	*Thamnophis radix*
Smooth Green Snake	*Opheodrys vernalis*

Table 4. Piscine species in the McDonald Lake region.

Common Name	Scientific Name
Brook Stickleback	*Culaea inconstans*
Fathead Minnow	*Pimephales promelas*
Common Shiner	*Luxilus cornutus*
Iowa Darter	*Etheostoma exile*
Johnny Darter	*Etheostoma nigrum*
White Sucker	*Catostomus commersoni*
Longnose Dace	*Rhinichthys cataractae*
Tadpole Madtom	*Noturus gyrinus*
Brassy Minnow	*Hybognathus hankinsoni*
Black Bullhead	*Ameiurus melas*
Blackside Darter	*Percina maculata*
Yellow Perch	*Perca flavescens*

APPENDIX II

FAUNAL DISTRIBUTION

Figure 1. Sanderson Site (DhMs-12) Block 7 west *Bison bison* immature element distribution, occupation 1.

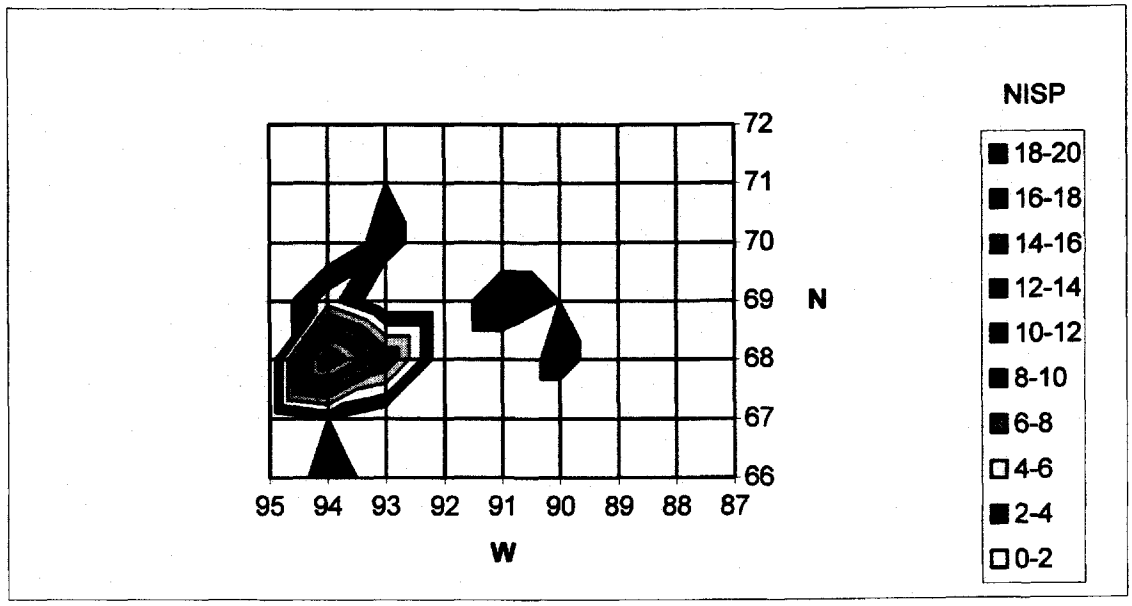


Figure 2, Sanderson Site (DhMs-12) Block 7 west *Bison bison* immature element distribution, occupation 2

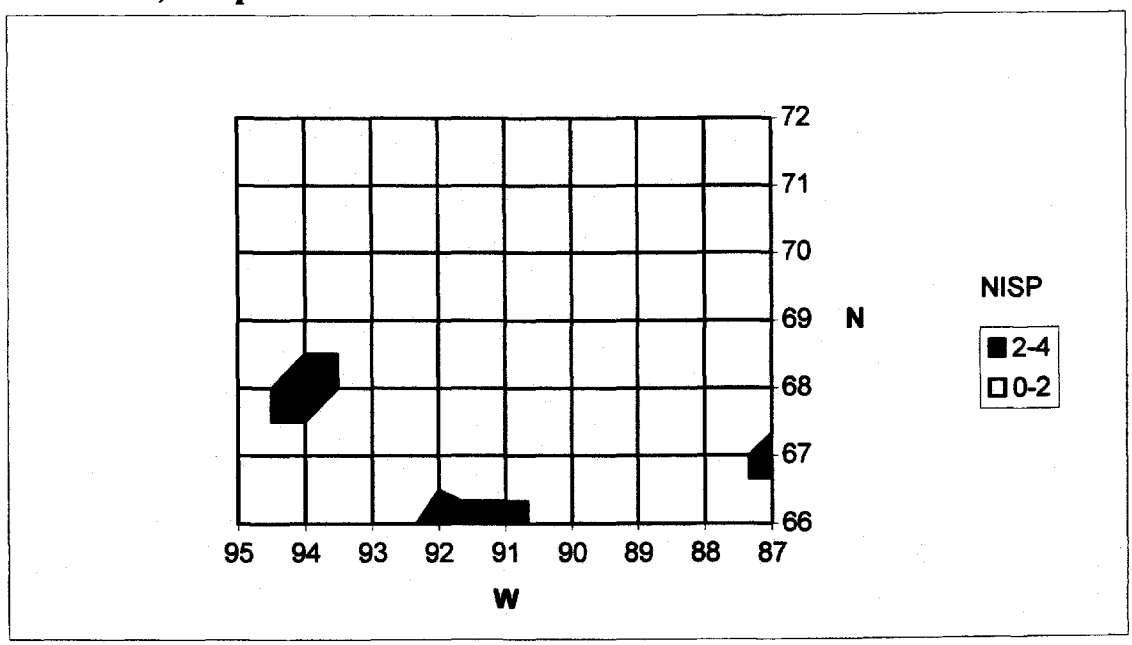


Figure 3. Sanderson Site (DhMs-12) Block 7 west *Bison bison* cranial element distribution, occupation 1

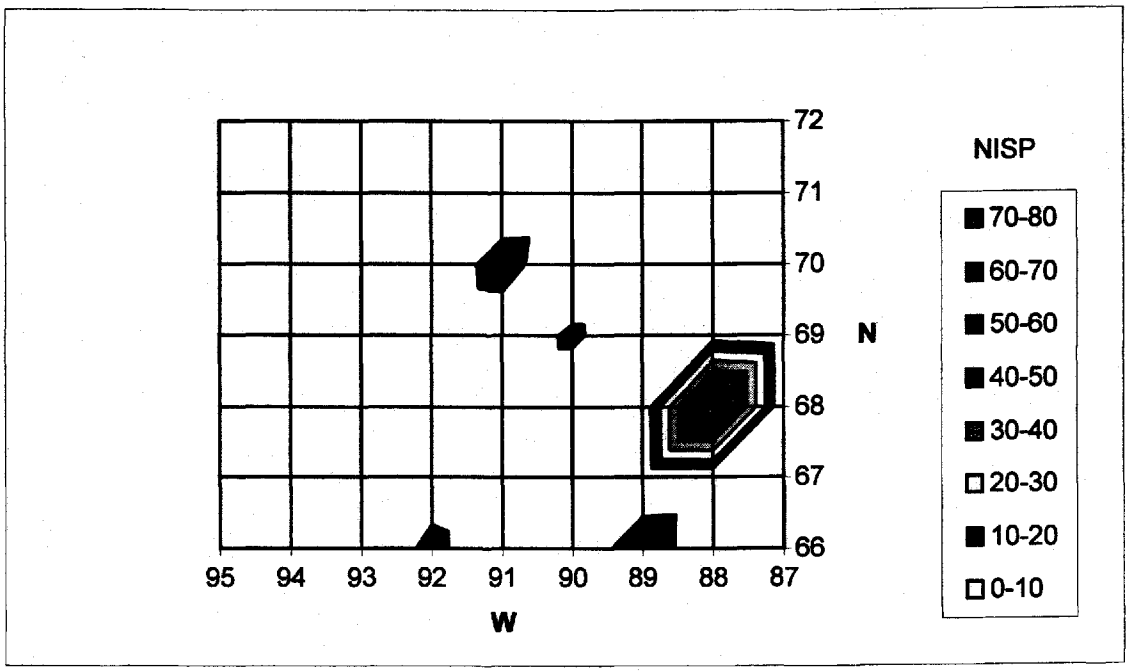


Figure 4. Sanderson Site (DhMs-12) Block 7 west *Bison bison* cranial element distribution, occupation 2

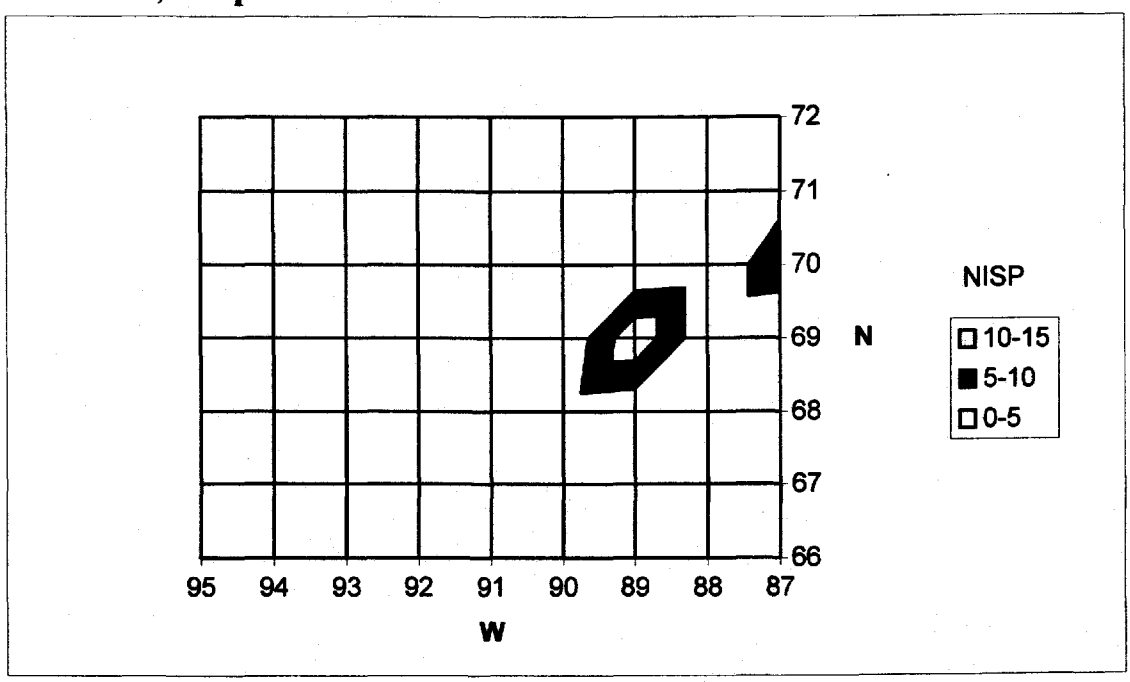


Figure 5. Sanderson Site (DhMs-12) Block 7 west *Bison bison* vertebral element distribution, occupation 1

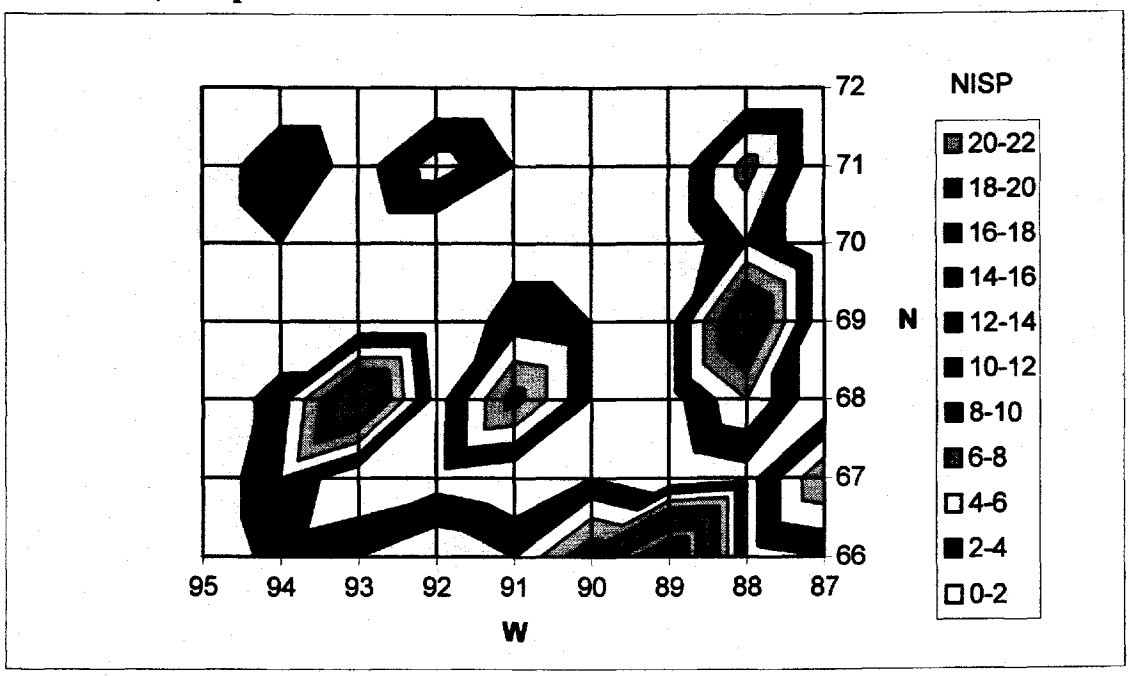


Figure 6. Sanderson Site (DhMs-12) Block 7 west *Bison bison* vertebral element distribution occupation 2.

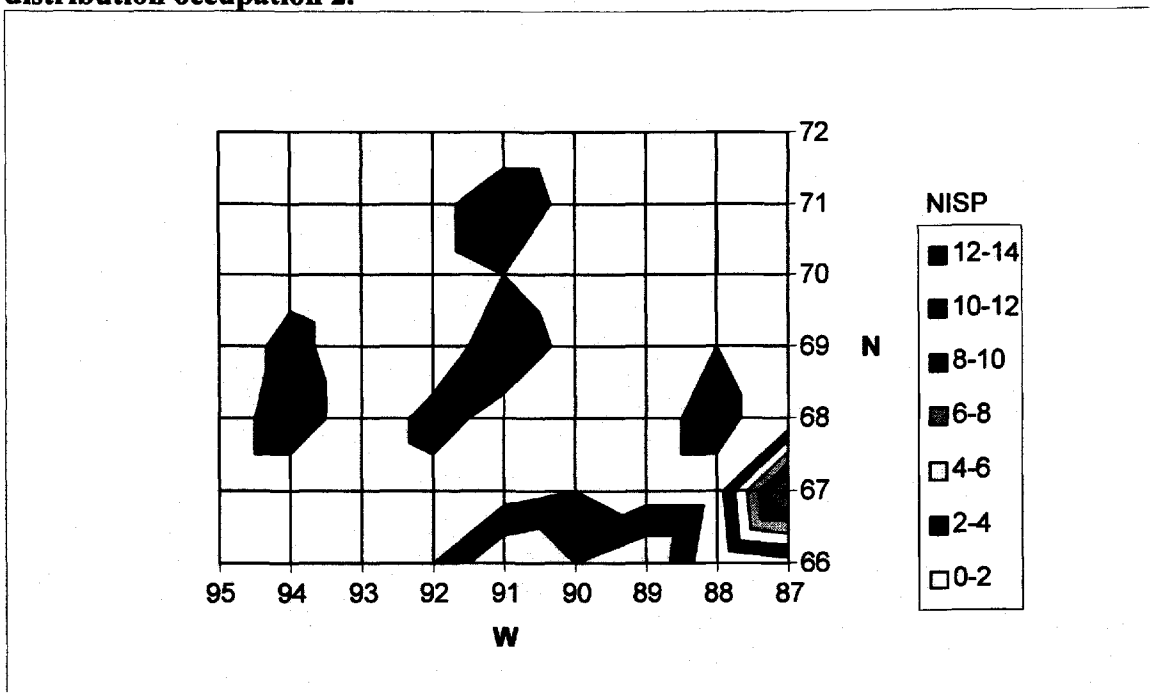


Figure 7. Sanderson Site (DhMs-12) Block 7 west *Bison bison* forelimb element distribution, occupation 1.

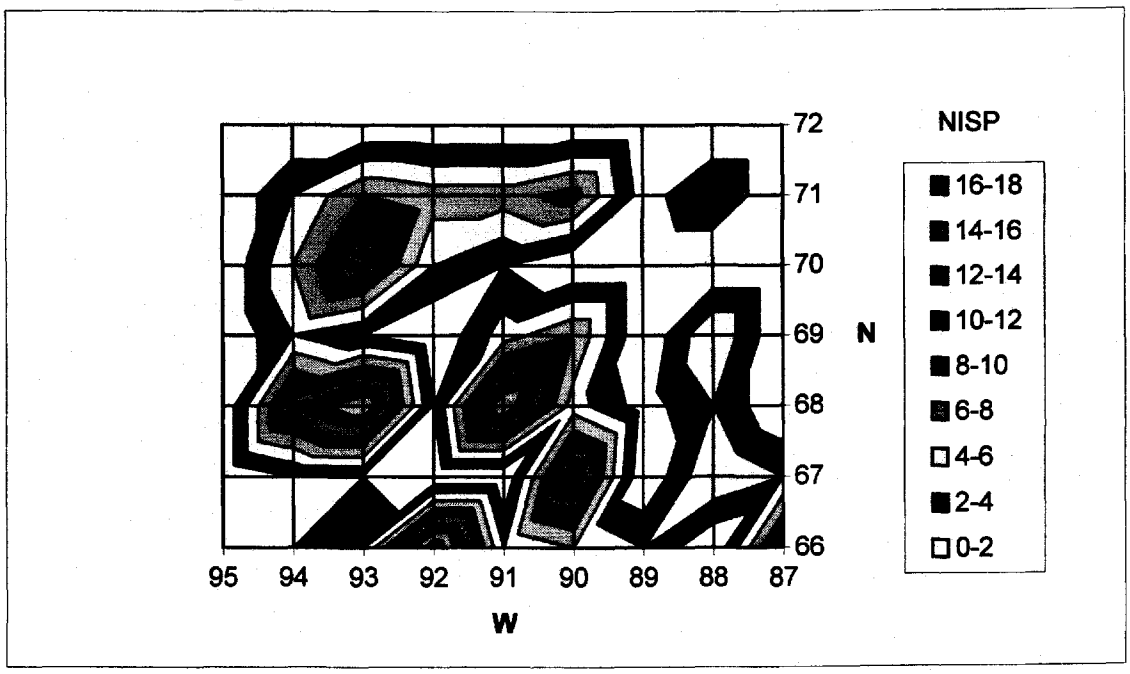


Figure 8. Sanderson Site (DhMs-12) Block 7 west *Bison bison* forelimb element distribution, occupation 2

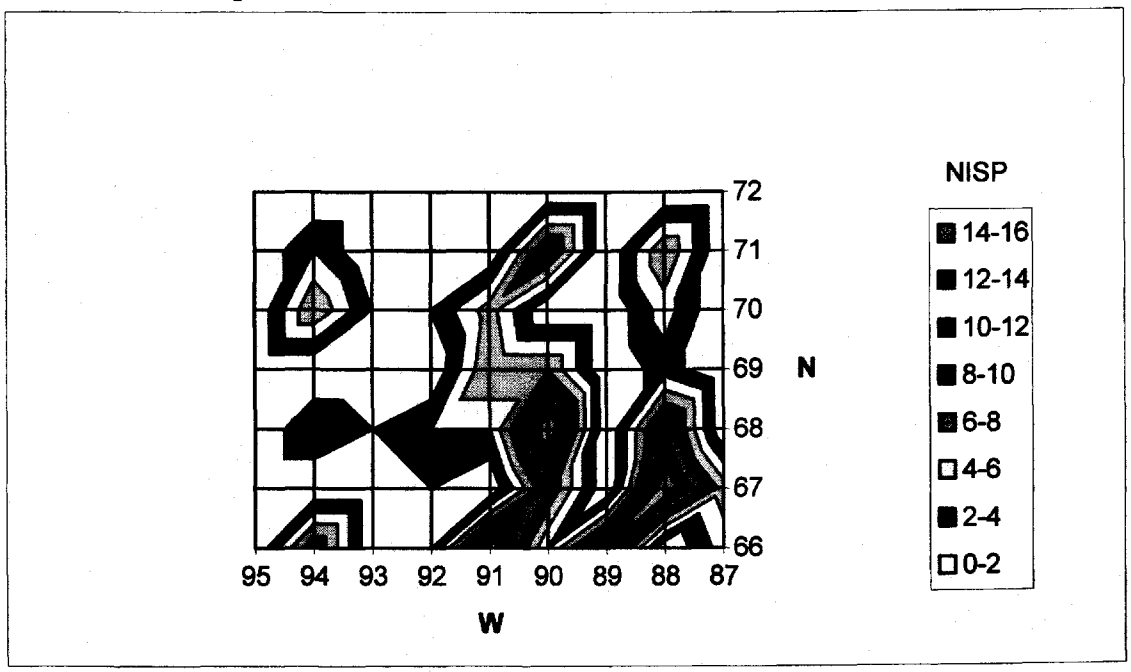


Figure 9. Sanderson Site (DhMs-12) Block 7 west *Bison bison* hindlimb element distribution, occupation 1.

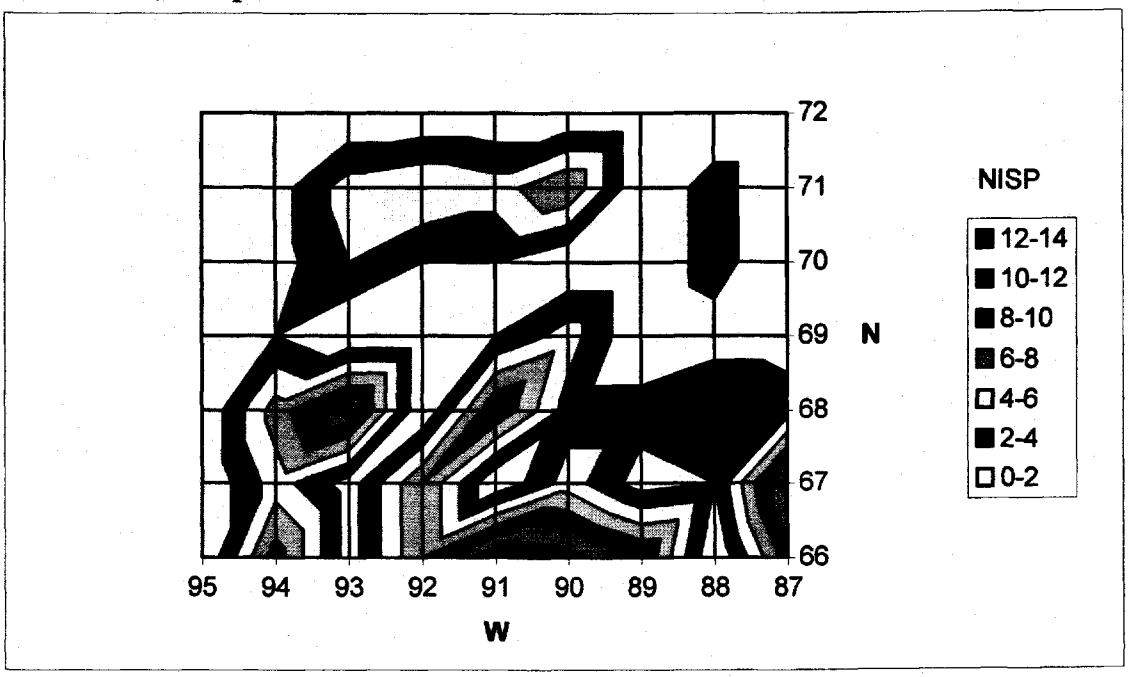


Figure 10. Sanderson Site (DhMs-12) Block 7 west *Bison bison* hindlimb element distribution, occupation 2.

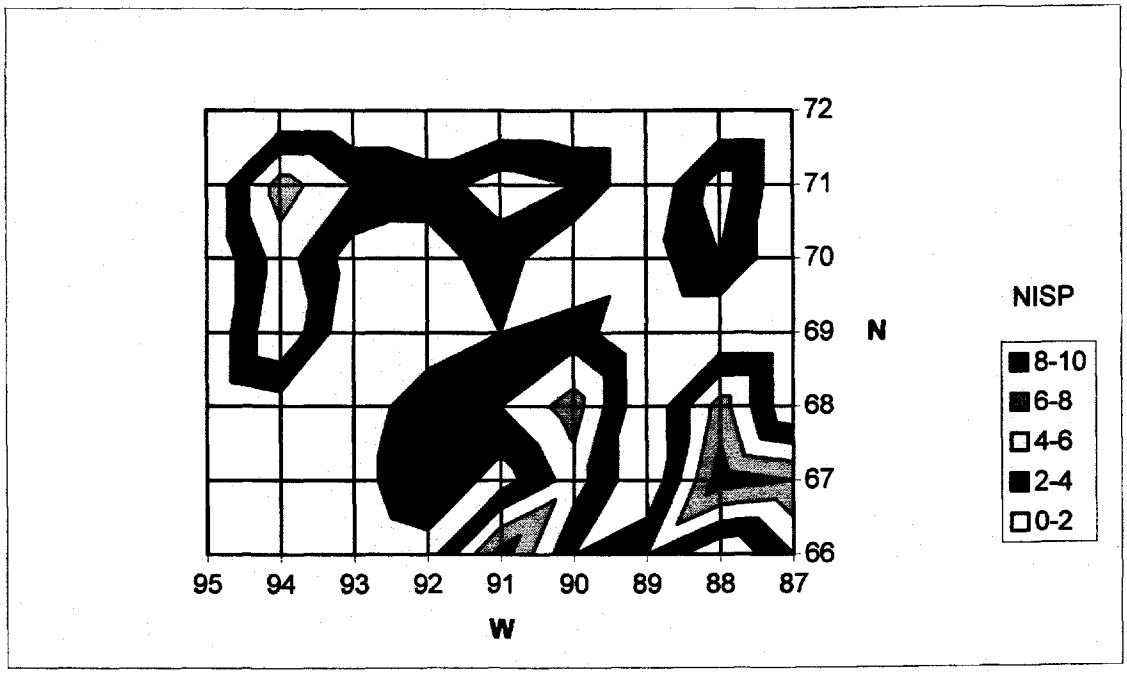


Figure 11. Sanderson Site (DhMs-12) Block 7 west *Bison bison* phalange element distribution, occupation 1.

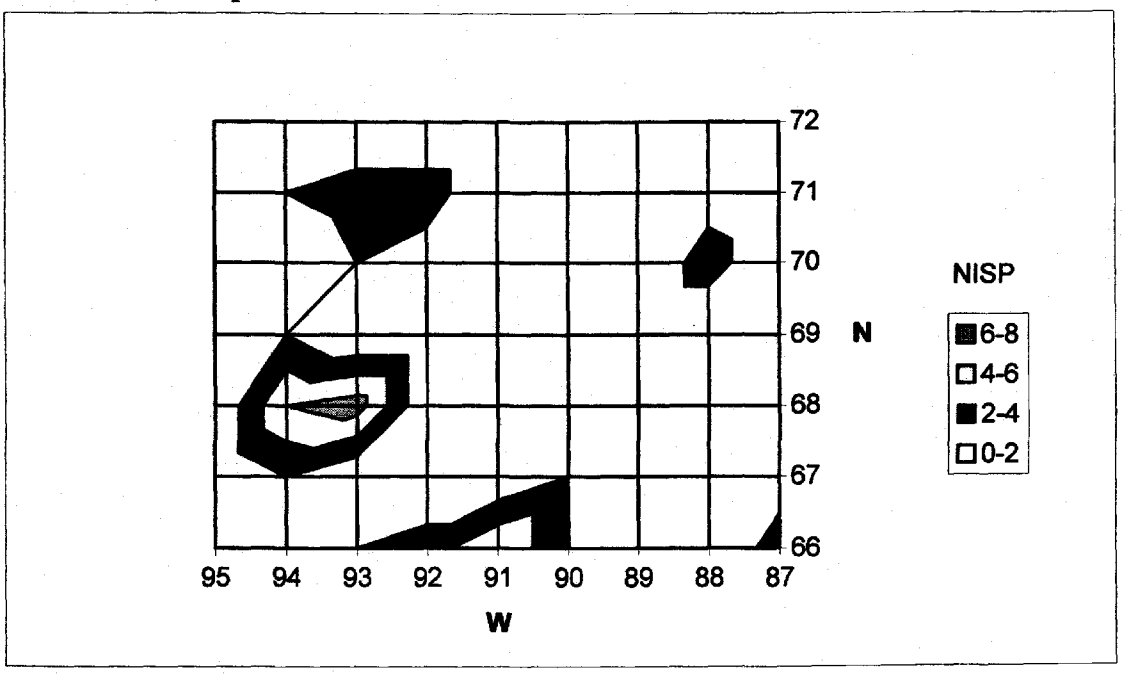


Figure 12. Sanderson Site (DhMs-12) Block 7 west *Bison bison* phalange element distribution occupation 2.

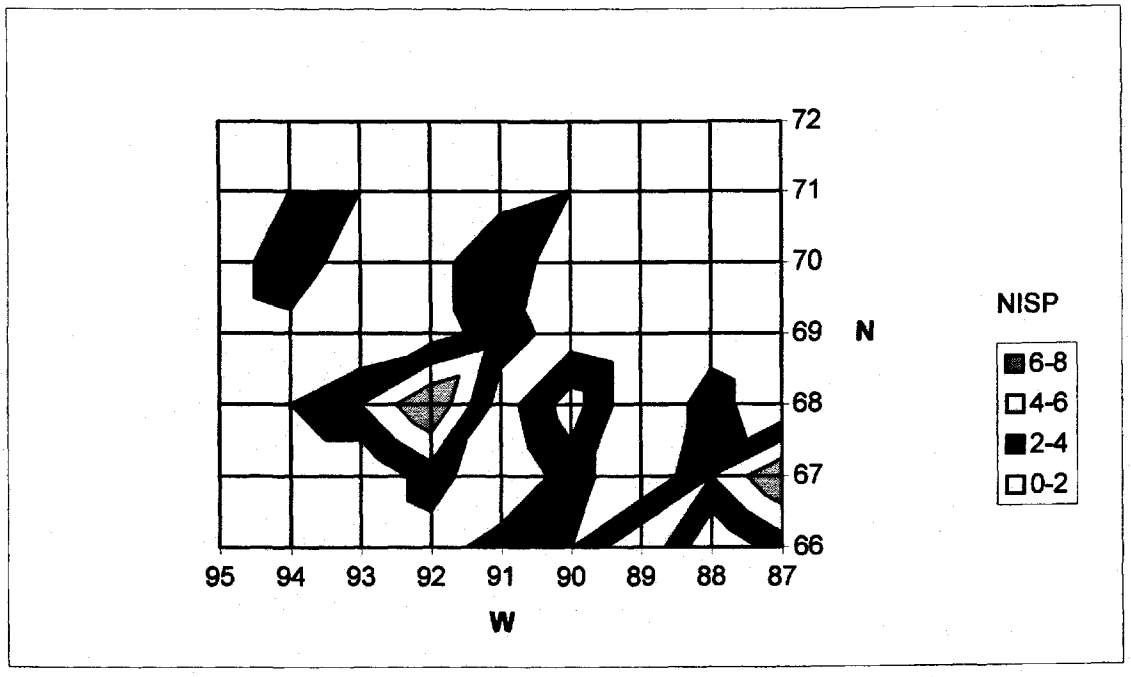


Figure 13. Sanderson Site (DhMs-12) Block 7 west *Bison bison* sesamoid distribution, occupation 1.

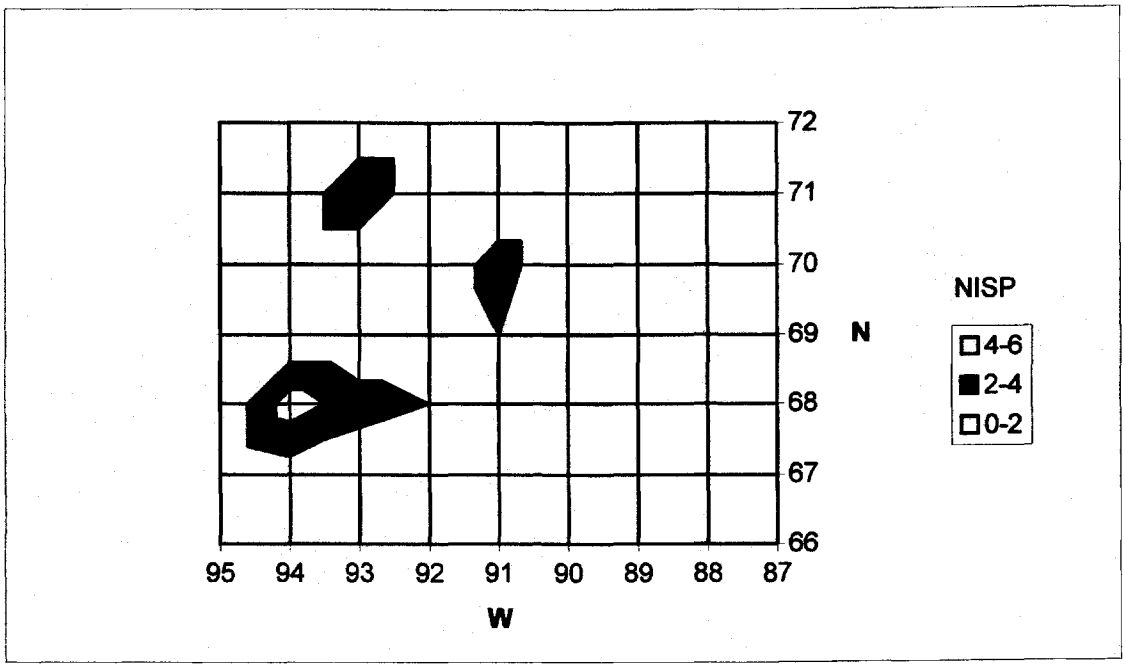


Figure 14. Sanderson Site (DhMs-12) Block 7 west *Bison bison* sesamoid distribution, occupation 2

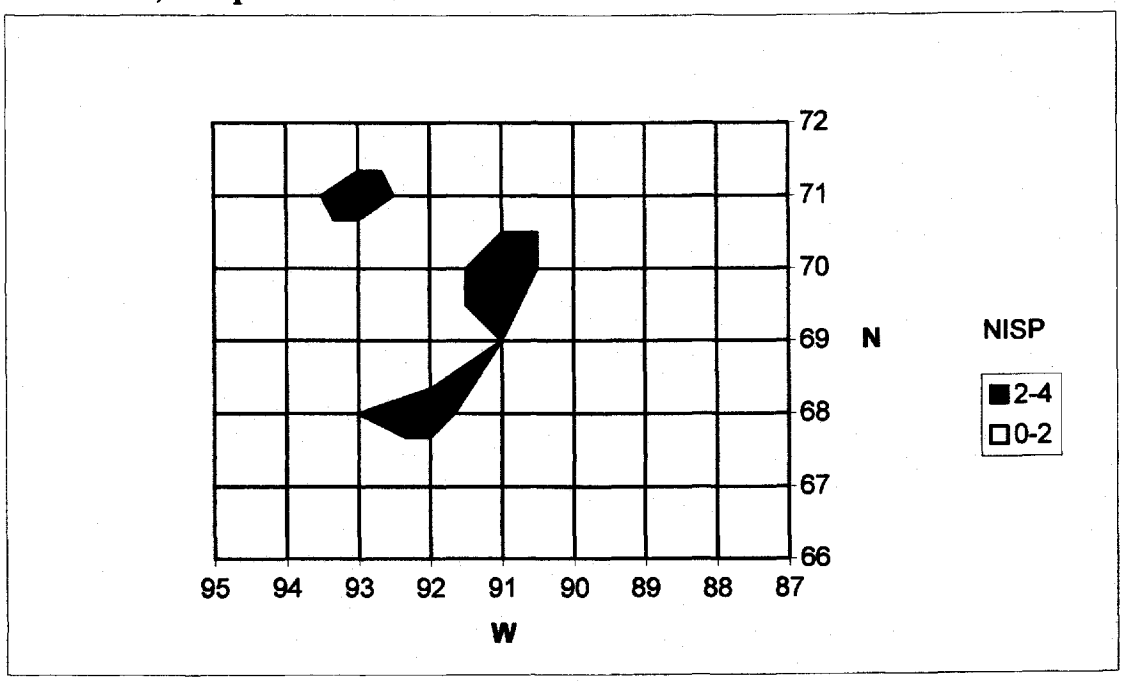


Figure 15. Sanderson Site (DhMs-12) Block 7 west *Vulpes velox* total element distribution, occupation 1.

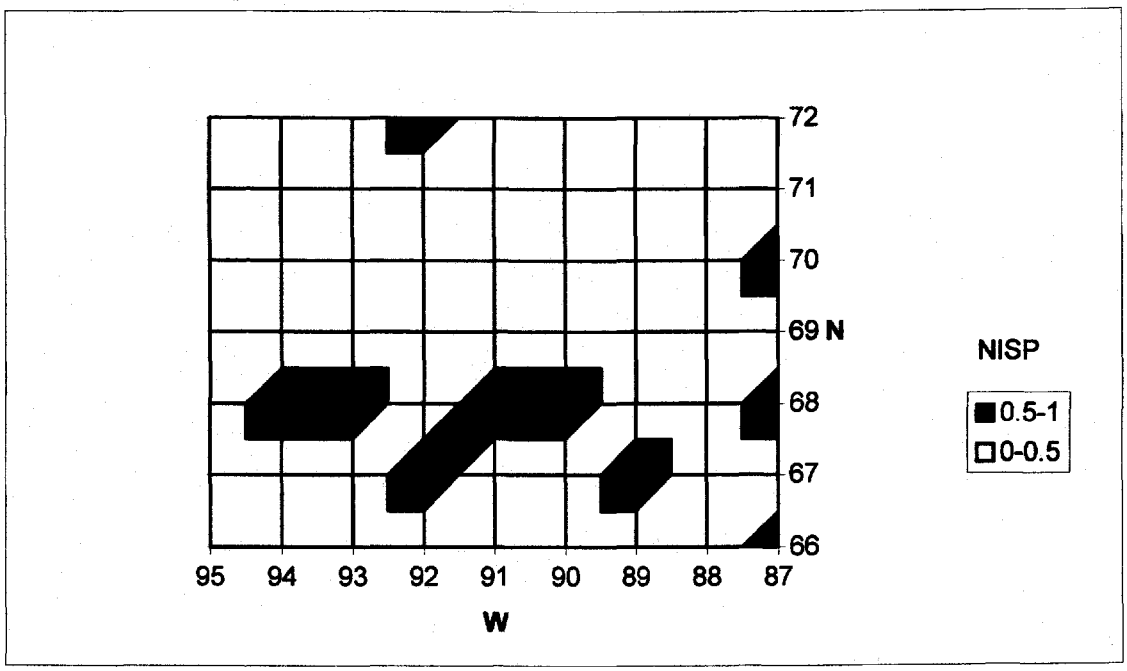


Figure 16. Sanderson Site (DhMs-12) Block 7 west small *Canis sp.* total element distribution, occupation 2.

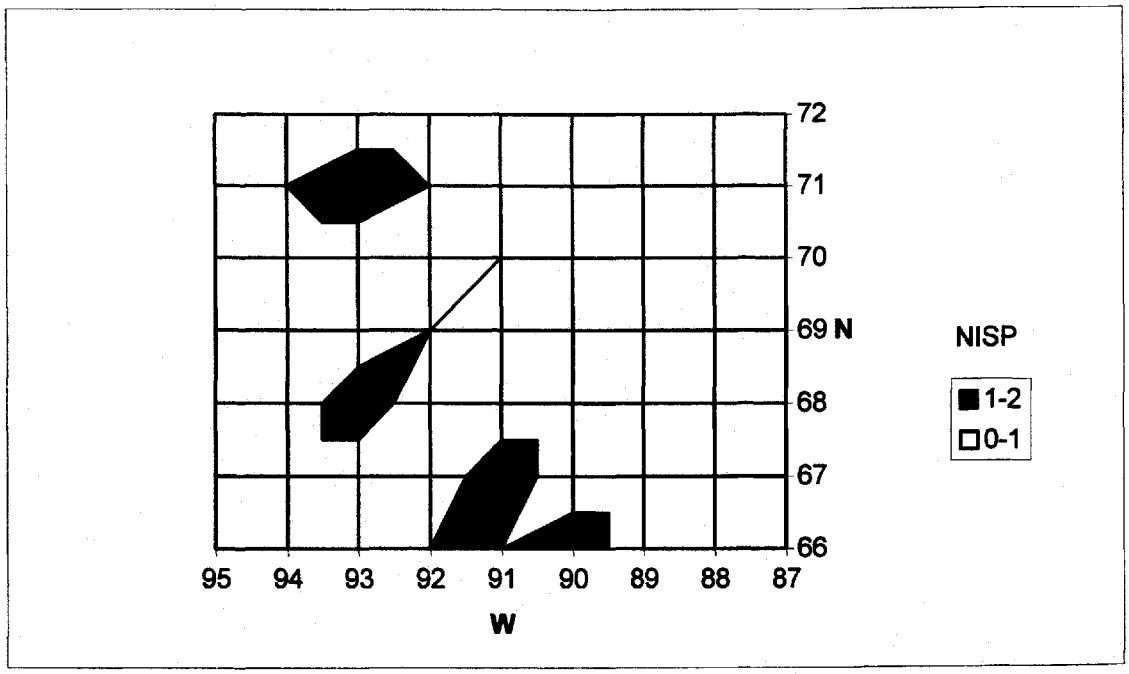


Figure 17. Sanderson Site (DhMs-12) Block 7 west large *Canis sp.* total element distribution, occupation 1.

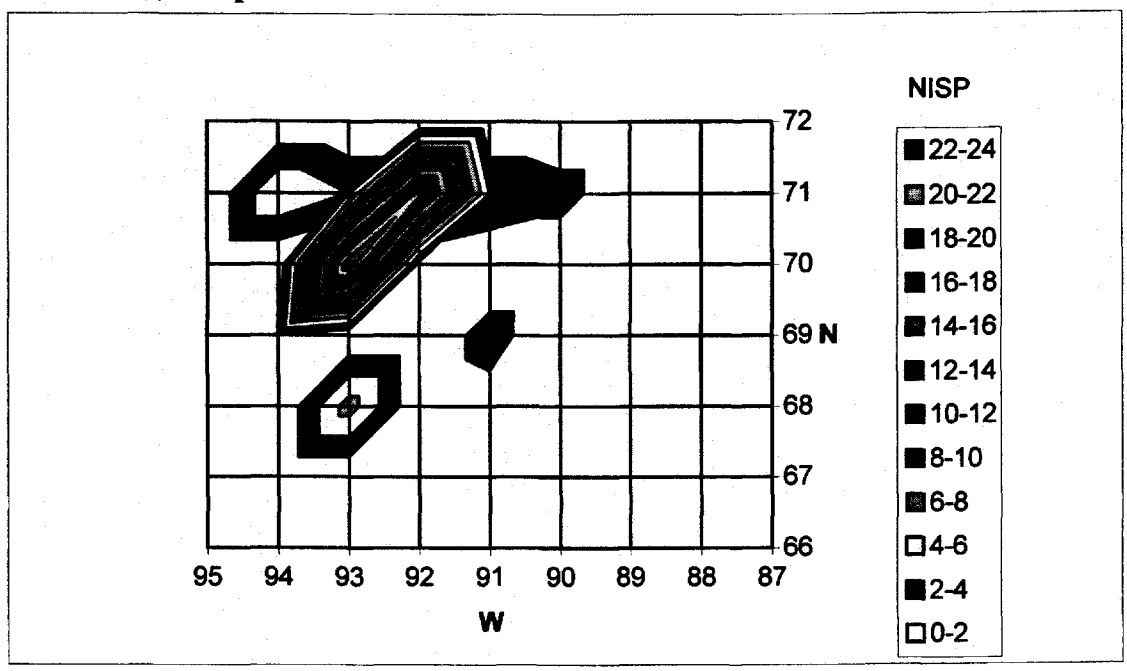


Figure 18. Sanderson Site (DhMs-12) Block 7 west large *Canis sp.* total element distribution, occupation 2.

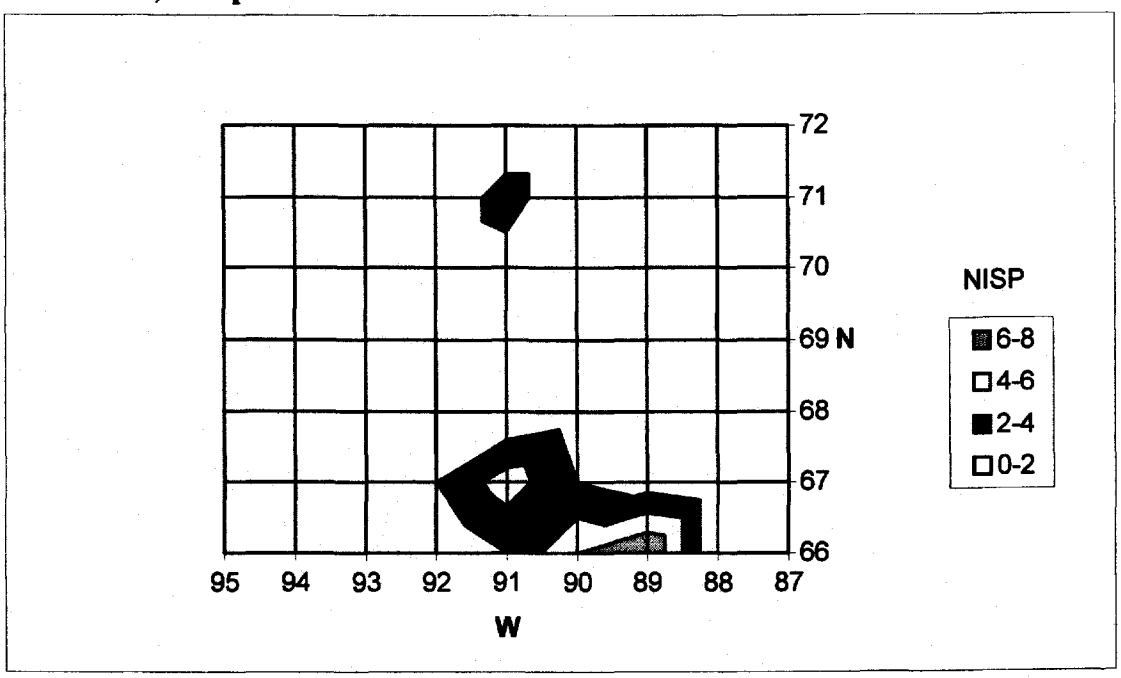


Figure 19. Sanderson Site (DhMs-12) Block 7 west rodent total element, occupation 1

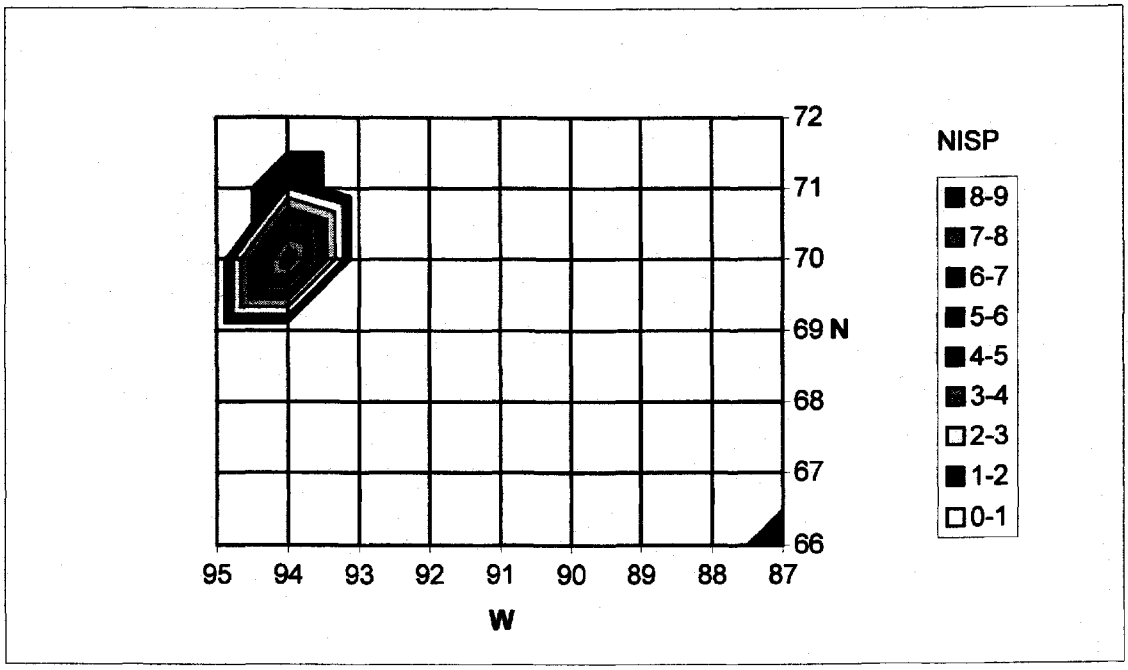


Figure 20. Sanderson Site (DhMs-12) Block 7 west rodent total element, occupation 2.

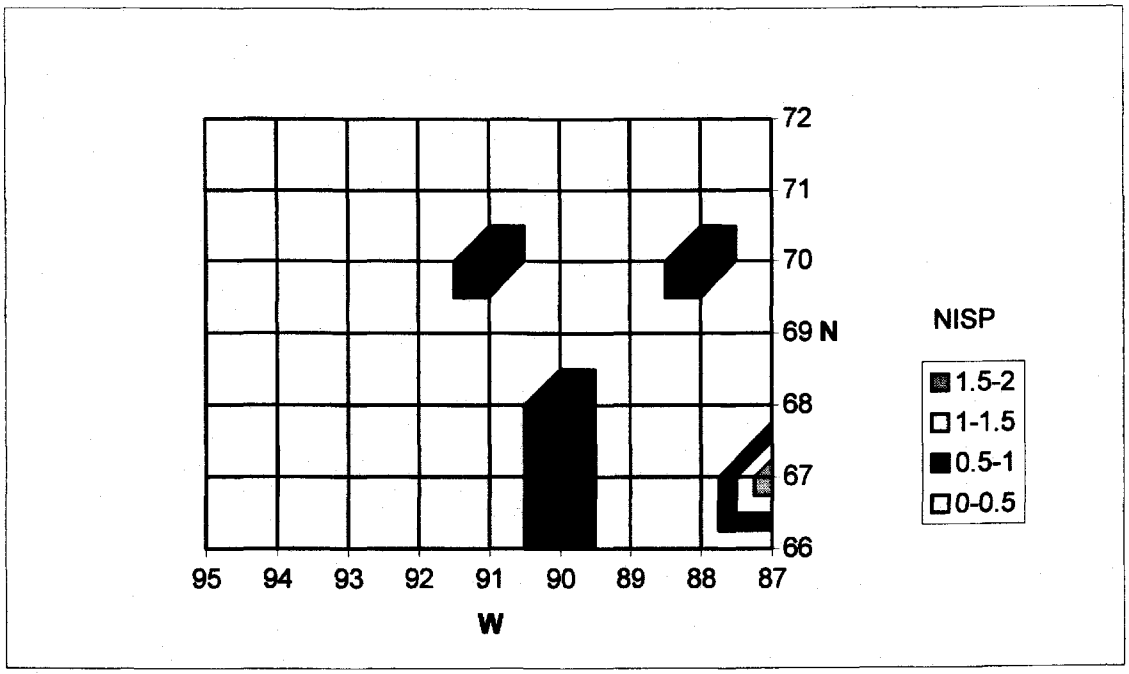


Figure 21. Sanderson Site (DhMs-12) Block 7 west bird total element distribution, Occupation 1.

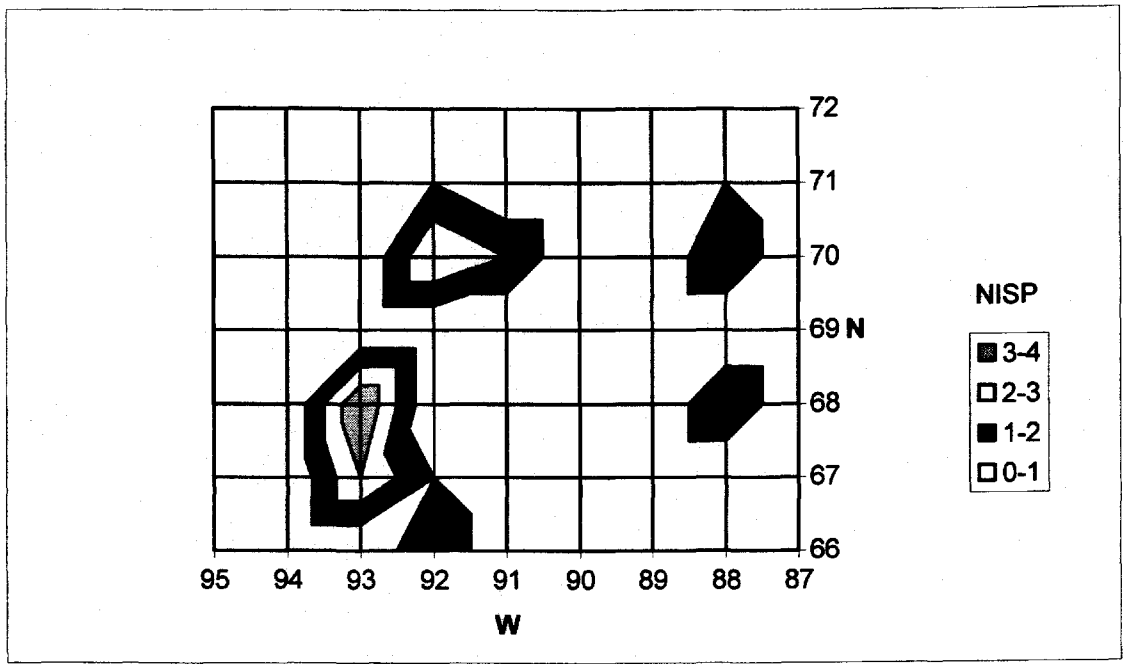
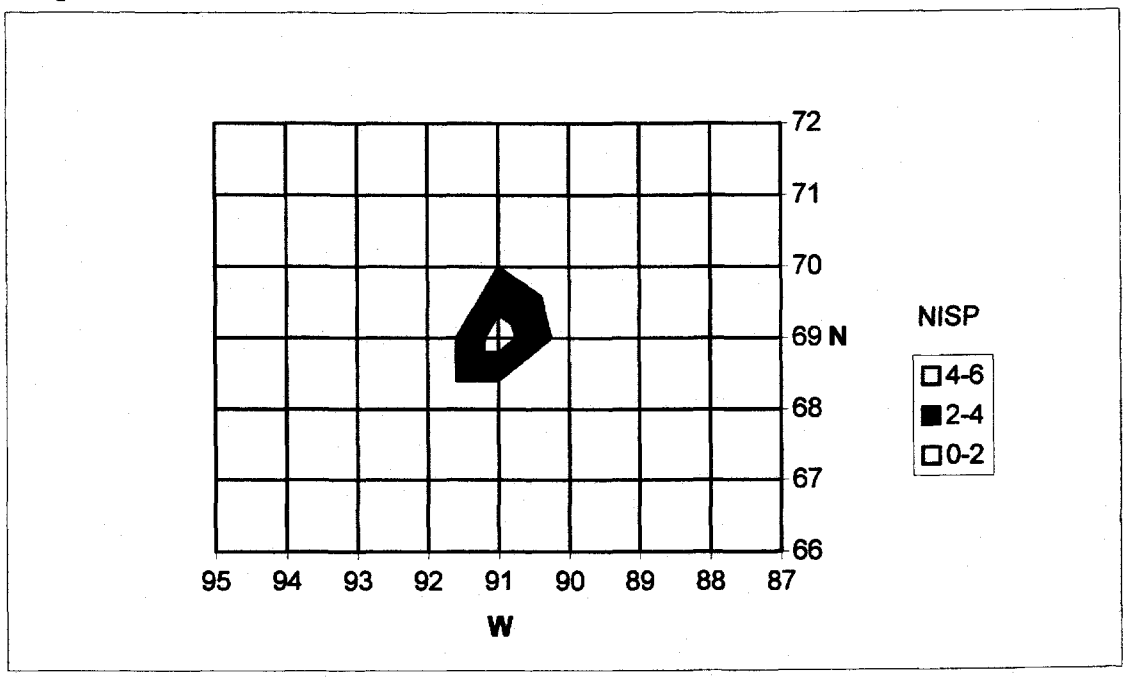


Figure 22. Sanderson Site (DhMs-12) Block 7 west bird total element distribution, occupation 2.



APPENDIX III

MINIMUM ANIMAL UNITS

Table 1. *Bison bison* element counts with scan sites and volume density at the Sanderson site.

	Occ 1 Total MNE	Total MAU	% MAU	Occ 2 Total MNE	Total MAU	%MAU	VD	Scan
Axial Elements								
Cranium								
Zygomatic of temporal	0.0	0.0	0.0	3.0	1.5	18.8	-	-
Premaxilla	5.0	2.5	33.3	1.0	0.5	6.3	-	-
Horn core	0.0	0.0	0.0	3.0	1.5	18.8	-	-
Mastoid process	1.0	0.5	6.7	0.0	0.0	0.0	-	-
Petrous portion	5.0	2.5	33.3	4.0	2.0	25.0	-	-
External auditory meatus	1.0	0.5	6.7	0.0	0.0	0.0	-	-
occipital condyle	0.0	0.0	0.0	0.0	0.0	0.0	-	-
basioccipital	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Frontal frag	1.0	0.5	6.7	0.0	0.0	0.0	-	-
Facial tuber	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Maxilla	0.0	0.0	0.0	0.0	0.0	0.0	-	-
P2 alv: tooth	8.0	4.0	53.3	11.0	5.5	68.8	-	-
P3 alv. tooth	1.0	0.5	6.7	4.0	2.0	25.0	-	-
P4 alv. tooth	0.0	0.0	0.0	2.0	1.0	12.5	-	-
M1 alv: tooth	15.0	7.5	100	9.0	4.5	56.3	-	-
M2 alv: tooth	4.0	2.0	26.7	4.0	2.0	25.0	-	-
M3 alv: tooth	0.0	0.0	0.0	2.0	1.0	12.5	-	-
Mandible								
Coronoid process (CP)	14.0	7.0	93.3	5.0	2.5	31.3	0.79	DN8
Articular condyle (AC)	5.0	2.5	33.3	7.0	3.5	43.8	0.79	DN7
Mandibular foramen (MF)	0.0	0.0	0.0	0.0	0.0	0.0	0.79	DN7
Angle of ramus (AN)	1.0	0.5	6.7	1.0	0.5	6.3	0.57	DN6
M3 alv: tooth	10.0	5.0	66.7	5.0	2.5	31.3	0.49	DN5
M2 alv: tooth	1.0	0.5	6.7	1.0	0.5	6.3	0.49	DN5
M1 alv: tooth	13.0	6.5	86.7	4.0	2.0	25.0	0.53	DN4
P4 alb: tooth	0.0	0.0	0.0	1.0	0.5	6.3	0.53	DN4
P3 alv: tooth	5.0	2.5	33.3	0.0	0.0	0.0	0.62	DN3
P2 alv: tooth	11.0	5.5	73.3	6.0	3.0	37.5	0.62	DN3
Lower border (LB)	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Diastema (DS)	0.0	0.0	0.0	0.0	0.0	0.0	0.61	DN2
Symphysis (SY)	10.0	5.0	66.7	2.0	1.0	12.5	0.53	DN1
Incisors/ canines (I)	24.0	3.0	40.0	5.0	2.5	31.3	0.53	DN1
Mental foramen	1.0	0.5	6.7	1.0	0.5	6.3	0.61	DN2
Ramus frag	0.0	0.0	0.0	0.0	0.0	0.0	-	-
deciduous incisors	2.0	1.0	13.3	0.0	0.0	0.0	-	-
deciduous P2 alv:tooth	1.0	0.5	6.7	0.0	0.0	0.0	-	-
deciduous P3 alv:tooth	0.0	0.0	0.0	0.0	0.0	0.0	-	-
deciduous P4 alv:tooth	1.0	0.5	6.7	0.0	0.0	0.0	-	-

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APPENDIX III

	Occ 1 Total MNE	Total MAU	% MAU	Occ 2 Total MNE	Total MAU	%MAU	VD	Scan
Hyoid	2.0	1.0	13.3	3.0	1.5	18.8	-	-
Sternum	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Rib head	43.0	1.7	22.1	3.0	0.1	1.4	-	-
Atlas								
Centrum	1.0	1.0	13.3	0.0	0.0	0.0	-	-
Epiphsis	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Anterior zygapophysis	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Posterior zygapophysis	0.0	0.0	0.0	1.0	1.0	12.5	-	-
Neural arch	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Neural spine	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Transverse spine	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Axis								
Centrum	2.0	2.0	26.7	1.0	1.0	12.5	-	-
Epiphsis	1.0	1.0	13.3	0.0	0.0	0.0	-	-
Anterior zygapophysis	4.0	2.0	26.7	0.0	0.0	0.0	-	-
Posterior zygapophysis	0.0	0.0	0.0	2.0	2.0	25.0	-	-
Neural arch	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Neural spine	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Transverse spine	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Cervical								
Centrum	5.0	0.7	9.5	2.0	0.3	3.6	-	-
Epiphsis	2.0	0.1	1.9	2.0	0.1	1.8	-	-
Anterior zygapophysis	6.0	0.4	5.7	8.0	0.6	7.1	-	-
Posterior zygapophysis	7.0	0.5	6.7	5.0	0.4	4.5	-	-
Neural arch	4.0	0.6	7.6	2.0	0.3	3.6	-	-
Neural spine	0.0	0.0	0.0	1.0	0.1	1.8	-	-
Transverse spine	3.0	0.2	2.9	0.0	0/0	0.0	-	-
Thoracic								
Centrum	9.0	0.7	9.2	3.0	0.2	2.9	-	-
Epiphsis	1.0	0.0	0.5	0.0	0.0	0.0	-	-
Anterior zygapophysis	5.0	0.2	2.6	2.0	0.1	1.0	-	-
Posterior zygapophysis	10.0	0.4	5.1	8.0	0.3	3.9	-	-
Neural arch	9.0	0.7	9.2	4.0	0.3	3.9	-	-
Neural spine	3.0	0.2	3.1	0.0	0.0	0.0	-	-
Transverse spine	13.0	0.5	6.7	4.0	0.2	1.9	-	-
Costal facet	18.0	0.7	9.2	5.0	0.2	2.4	-	-
Tubercular facet	11.0	0.4	5.6	0.0	0.0	0.0	-	-

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	Occ 1 Total MNE	Total MAU	% MAU	Occ 2 Total MNE	Total MAU	%MAU	VD	Scan
Lumbar								
Centrum	8.0	1.3	17.8	3.0	0.5	6.3	-	-
Epiphsis	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Anterior zygapophysis	8.0	0.7	8.9	6.0	0.5	6.3	-	-
Posterior zygapophysis	17.0	1.4	18.9	7.0	0.6	7.3	-	-
Neural arch	3.0	0.3	3.3	3.0	0.3	3.1	-	-
Neural spine	2.0	0.3	4.4	0.0	0.0	0.0	-	-
Transverse spine	2.0	0.3	4.4	1.0	0.2	2.1	-	-
Sacral	6.0	6.0	80.0	2.0	2.0	25.0	-	-
Caudal	3.0	0.2	2.0	4.0	0.2	2.5	-	-
Forelimb								
Scapula								
Glenoid cavity (GC)	3.0	1.5	20	2.0	1.0	12.5	0.50	SP1
Coracoid process (CP)	0.0	0.0	0.0	0.0	0.0	0.0	0.50	SP1
Neck (Nk)	0.0	0.0	0.0	0.0	0.0	0.0	0.50	SP1
Spinous process (SP)	0.0	0.0	0.0	0.0	0.0	0.0	0.48	SP2
Acromion (AC)	0.0	0.0	0.0	0.0	0.0	0.0	0.48	SP2
Superior border	0.0	0.0	0.0	0.0	0.0	0.0	0.28	SP3
Inferior border	0.0	0.0	0.0	0.0	0.0	0.0	0.17	SP5
Humerus								
Lateral tuberosity (LT)	0.0	0.0	0.0	2.0	1.0	12.5	0.24	HU1
Medial tuberosity (MT)	1.0	0.5	6.7	0.0	0.0	0.0	0.24	HU1
Head (H)	0.0	0.0	0.0	1.0	0.5	6.3	0.24	HU1
Proximal epiphysis	0.0	0.0	0.0	1.0	0.5	6.3	-	-
Proximal shaft (PS)	0.0	0.0	0.0	0.0	0.0	0.0	0.25	HU2
Deltoid tuberosity (DT)	8.0	4.0	53.3	3.0	1.5	18.8	0.25	HU2
Teres tuberosity (TT)	7.0	3.5	46.7	6.0	3.0	37.5	0.45	HU3
Teres minor tuberosity (TM)	2.0	1.0	13.3	2.0	1.0	12.5	0.25	HU2
Postero-lateral foramen (PLF)	6.0	3.0	40.0	9.0	4.5	56.3	0.45	HU3
Prox. Olecranon fossa (POF)	5.0	2.5	33.3	7.0	3.5	43.8	0.48	HU4
Radial fossa (CF)	6.0	3.0	40.0	7.0	3.5	43.8	0.48	HU4
Lateral epicondyle (LE)	6.0	3.0	40.0	4.0	2.0	25.0	0.38	HU5
Medial epicondyle (LE)	8.0	4.0	53.3	5.0	2.5	31.3	0.38	HU5
Lateral condyle (LC)	8.0	4.0	53.3	10.0	5.0	62.5	0.38	HU5
Medial condyle (MC)	8.0	4.0	53.3	10.0	5.0	62.5	0.38	HU5

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APPENDIX III

	Occ 1 Total MNE	Total MAU	% MAU	Occ 2 Total MNE	Total MAU	%MAU	VD	Scan
Radius								
Lateral glenoid cavity (LGC)	6.0	3.0	40.0	3.0	1.5	18.8	0.48	RA1
Medial glenoid cavity (MGC)	13.0	6.5	86.7	6.0	3.0	37.5	0.48	RA1
Prox. posterior shaft (PPS)	1.0	0.5	6.7	0.0	0.0	0.0	0.56	RA2
Radial tuberosity (RT)	0.0	0.0	0.0	0.0	0.0	0.0	0.56	RA2
Postero-lateral foramen (PLF)	5.0	2.5	33.3	2.0	1.0	12.5	0.56	RA2
mid-posterior shaft (MPS)	3.0	1.5	20.0	1.0	0.5	6.3	0.62	RA3
mid-anterior shaft (MAS)	2.0	1.0	13.3	2.0	1.0	12.5	0.62	RA3
distal-posterior shaft (DPS)	1.0	0.5	6.7	0.0	0.0	0.0	0.42	RA4
distal-anterior shaft (DAS)	0.0	0.0	0.0	1.0	0.5	6.3	0.42	RA4
radial carpal facet (RCF)	9.0	4.5	60.0	2.0	1.0	12.5	0.35	RA5
internal carpal facet (ICF)	3.0	1.5	20.0	2.0	1.0	12.5	0.35	RA5
Ulna								
Proximal epiphysis (Pe)	0.0	0.0	0.0	0.0	0.0	0.0	0.34	UL1
Olecranon process (OP)	5.0	2.5	33.3	5.0	2.5	31.3	0.34	UL1
Anconeal process (AP)	3.0	1.5	20.0	3.0	1.5	18.8	0.69	UL2
Semilunar notch (AF)	3.0	1.5	20.0	6.0	3.0	37.5	0.69	UL2
Coronoid process	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Proximal shaft (PS)	1.0	0.5	6.7	1.0	0.5	6.3	0.56	RA2
Mid-shaft (MS)	5.0	2.5	33.3	3.0	1.5	18.8	0.62	RA3
Styloid process (SP)	6.0	3.0	40.0	4.0	2.0	25.0	0.35	RA5
Radial carpal								
Anterior carpal	10.0	5.0	66.7	7.0	3.5	43.8	-	-
Posterior carpal	8.0	4.0	53.3	7.0	3.5	43.8	-	-
Internal carpal								
Anterior carpal	11.0	5.5	73.3	9.0	4.5	56.3	-	-
Posterior carpal	7.0	3.5	46.7	9.0	4.5	56.3	-	-
Ulnar carpal								
Anterior carpal	10.0	5.0	66.7	8.0	4.0	50.0	-	-
Posterior carpal	9.0	4.5	60.0	8.0	4.0	50.0	-	-
Accessory carpal	4.0	2.0	26.7	4.0	2.0	25.0	-	-
Carpal 2+3								
Lateral carpal	7.0	3.5	46.7	9.0	4.5	56.3	-	-
Medial carpal	9.0	4.5	60.0	9.0	4.5	56.3	-	-
Carpal 4 (Unciform)								
Anterior carpal	6.0	3.0	40.0	7.0	3.5	43.8	-	-
Posterior carpal	7.0	3.5	46.7	6.0	3.0	37.5	-	-

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	Occ 1 Total MNE	Total MAU	% MAU	Occ 2 Total MNE	Total MAU	%MAU	VD	Scan
Metacarpal								
Carpal 2+3 facet (C3F)	6.0	3.0	40.0	5.0	2.5	31.3	0.59	MC1
Carpal 4 facet (C4F)	3.0	1.5	20.0	3.0	1.5	18.8	0.59	MC1
Anterior shaft (AS)	2.0	1.0	13.3	1.0	0.5	6.3	0.63	MC2
Posterior shaft (PS)	2.0	1.0	13.3	0.0	0.0	0.0	0.63	MC2
Ant. foramen prox. (AFP)	2.0	1.0	13.3	0.0	0.0	0.0	0.63	MC2
Ant. foramen dist. (AFD)	4.0	2.0	26.7	2.0	1.0	12.5	0.60	MC4
Post. foramen prox. (PFP)	3.0	1.5	20.0	0.0	0.0	0.0	0.63	MC2
Post. foramen dist. (PFD)	4.0	2.0	26.7	2.0	1.0	12.5	0.60	MC4
Medial condyle (MC)	4.0	2.0	26.7	2.0	1.0	12.5	0.53	MC6
Lateral condyle (LC)	4.0	2.0	26.7	2.0	1.0	12.5	0.53	MC6
Distal epiphysis	0.0	0.0	0.0	0.0	0.0	0.0	-	-
Hindlimb								
Innominate								
Ilium blade (ILb)	2.0	1.0	13.3	0.0	0.0	0.0	0.22	IL1
Ilium shaft (ILs)	1.0	0.5	6.7	0.0	0.0	0.0	0.52	IL2
Ilio-ischial border (IIb)	1.0	0.5	6.7	0.0	0.0	0.0	0.53	AC1
Acetabulum- Ilium (ACIl)	6.0	3.0	40.0	1.0	0.5	6.3	0.53	AC1
Acetabulum- Isch. (ACIs)	3.0	1.5	20.0	5.0	2.5	31.3	0.53	AC1
Acetabulum- Pubis (ACIp)	4.0	2.0	26.7	1.0	0.5	6.3	0.53	AC1
Ischium shaft (ISs)	2.0	1.0	13.3	2.0	1.0	12.5	0.50	IS1
Ischial tuber (ISt)	4.0	2.0	26.7	1.0	0.5	6.3	0.19	IS2
Pubis shaft (PUs)	1.0	0.5	6.7	0.0	0.0	0.0	0.55	PU1
Pubis symphysis (PSY)	1.0	0.5	6.7	0.0	0.0	0.0	0.39	PU2
Femur								
Head (H)	11.0	5.5	73.3	1.0	0.5	6.3	0.31	FE1
Great Trochanter (GT)	0.0	0.0	0.0	0.0	0.0	0.0	0.22	FE7
Lesser Trochanter (LT)	5.0	2.5	33.3	1.0	0.5	6.3	0.34	FE3
Anterior shaft (AS)	0.0	0.0	0.0	1.0	0.5	6.3	0.45	FE4
Linea Aspera (LA)	3.0	1.5	20.0	4.0	2.0	25.0	0.45	FE4
Post-Med foramen (PMF)	4.0	2.0	26.7	2.0	1.0	12.5	0.36	FE5
Supracondyloid fossa (SF)	2.0	1.0	13.3	9.0	4.5	56.3	0.36	FE5
Prox. Trochlea (PT)	0.0	0.0	0.0	0.0	0.0	0.0	0.26	FE6
Medial condyle (MC)	4.0	2.0	26.7	0.0	0.0	0.0	0.26	FE6
Lateral condyle (LC)	0.0	0.0	0.0	0.0	0.0	0.0	0.26	FE6
Medial epicondyle (ME)	0.0	0.0	0.0	1.0	0.5	6.3	0.26	FE6
Patella	3.0	1.5	20.0	6.0	3.0	37.5	-	-

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APPENDIX III

	Occ 1 Total MNE	Total MAU	% MAU	Occ 2 Total MNE	Total MAU	%MAU	VD	Scan
Tibia								
Tibial tuberosity (TT)	0.0	0.0	0.0	0.0	0.0	0.0	0.41	TI1
Medial condyle (MC)	2.0	1.0	13.3	0.0	0.0	0.0	0.41	TI1
Lateral condyle (LC)	4.0	2.0	26.7	0.0	0.0	0.0	0.41	TI1
Proximal epiphysis (Pe)	1.0	0.5	6.7	0.0	0.0	0.0	0.41	TI1
Anterior crest (AC)	15.0	7.5	100.0	11.0	5.5	68.8	0.58	TI2
Posterolateral foramen (PLF)	7.0	3.5	46.7	10.0	5.0	62.5	0.58	TI2
Prox. posterior shaft (PPS)	3.0	1.5	20.0	0.0	0.0	0.0	0.76	TI3
Distal-posterior shaft (DPS)	4.0	2.0	26.7	0.0	0.0	0.0	0.44	TI4
Distal-anterior shaft (DAS)	5.0	2.5	33.3	1.0	0.5	6.3	0.44	TI4
Medial groove (MG)	14.0	7.0	93.3	15.0	7.5	93.8	0.41	TI5
Lateral groove (LG)	15.0	7.5	100.0	14.0	7.0	87.5	0.41	TI5
Fibular facet (FF)	6.0	3.0	40.0	9.0	4.5	56.3	0.41	TI5
Distal epiphysis (De)	1.0	0.5	6.7	0.0	0.0	0.0	0.41	TI5
Calcaneous								
Proximal epiphysis (Pe)	1.0	0.5	6.7	1.0	0.5	6.3	0.46	CA1
Tuber Calcis (TC)	3.0	1.5	20.0	7.0	3.5	43.8	0.80	CA2
Sustentaculaum (ST)	4.0	2.0	26.7	6.0	3.0	37.5	0.49	CA3
Fibular facet (FF)	5.0	2.5	33.3	10.0	5.0	62.5	0.66	CA4
Tarsal C+4 facet (CF)	2.0	1.0	13.3	9.0	4.5	56.3	0.66	CA4
Astragalus								
Proximal condyles (APC)	6.0	3.0	40.0	14.0	7.0	87.5	-	-
Distal condyles (ADC)	6.0	3.0	40.0	9.0	4.5	56.3	-	-
Tarsal C+4								
Lateral	13.0	6.5	86.7	5.0	2.5	31.3	-	-
Medial	15.0	7.5	100.0	2.0	1.0	12.5	-	-
Prox. medial projection	9.0	4.5	60.0	4.0	2.0	25.0	-	-
Tarsal 2+3	13.0	6.5	86.7	11.0	5.5	68.8	-	-
Tarsal 1	2.0	1.0	13.3	1.0	0.5	6.3		
Lateral malleolus	11.0	5.5	73.3	16.0	8.0	100.0	-	-
2nd metatarsal	1.0	0.5	6.7	1.0	0.5	6.3	-	-
5th metatarsal	3.0	1.5	20.0	5.0	2.5	31.3	-	-

con't

	Occ 1 Total MNE	Total MAU	% MAU	Occ 2 Total MNE	Total MAU	%MAU	VD	Scan
Metatarsal								
Tarsal C+4 facet (TCF)	4.0	2.0	26.7	9.0	4.5	56.3	0.52	MR1
Tarsal 2+3 facet (T2F)	3.0	1.5	20.0	5.0	2.5	31.3	0.52	MR1
Anterior shaft (AS)	2.0	1.0	13.3	2.0	1.0	12.5	0.59	MR2
Posterior shaft (PS)	2.0	1.0	13.3	0.0	0.0	0.0	0.59	MR2
Ant. foramen prox. (AFP)	2.0	1.0	13.3	3.0	1.5	18.8	0.59	MR2
Ant. foramen dist. (AFD)	0.0	0.0	0.0	0.0	0.0	0.0	0.51	MR4
Post. foramen prox. (PFP)	0.0	0.0	0.0	2.0	1.0	12.5	0.59	MR2
Post. foramen dist. (PFD)	0.0	0.0	0.0	0.0	0.0	0.0	0.51	MR4
Medial condyle (MC)	1.0	0.5	6.7	1.0	0.5	6.3	0.48	MR6
Lateral condyle (LC)	1.0	0.5	6.7	1.0	0.5	6.3	0.48	MR6
Fused 2nd tarsal	0.0	0.0	0.0	3.0	1.5	18.8	0.52	MR1
Other								
Appendicular								
1st phalanx								
Prox. 1st phalanx (1PP)	21.0	2.6	34.7	16.0	2.0	25.0	0.48	P11
Dist. 1st phalanx (1PD)	21.0	2.6	34.7	21.0	2.6	32.5	0.48	P13
2nd phalanx								
Prox. 2nd phalanx (2PP)	35.0	4.3	57.3	33.0	4.1	51.3	0.41	P21
Dist. 2nd phalanx (2PD)	35.0	4.3	57.3	38.0	4.8	60.0	-	-
3rd phalanx								
Prox. 3rd phalanx (3PP)	9.0	1.1	14.7	14.0	1.8	22.5	0.32	P31
Dist. 3rd phalanx (3PD)	9.0	1.1	14.7	9.0	1.1	13.8	0.32	P31
Sesamoids								
Superior-lateral	26.0	3.25	43.3	27.0	3.4	42.5	-	-
Superior-medial	24.0	3.0	40.0	19.0	3.6	45.0	-	-
Inferior	12.0	1.5	20.0	17.0	2.1	26.25	-	-

APPENDIX IV

BISON UTILITY INDICES

Table 1 Emerson's (S)MAVGTP index and %MAU based on landmarks and %MAU based on complete elements for occupation one.

Occupation one	Landmarks			Complete	
Element	(S)MAVGTP Value	%MAU	%MAU Rank	%MAU	%MAU Rank
Cranium	14.2	100	18.5	100	17.5
Atlas	6.4	13.3	3.5	13.3	3.5
Axis	7.8	26.7	6.5	26.7	6.5
Cervical	56.6	9.5	3	9.5	3
Thoracic	84.7	9.2	2	9.2	2
Lumbar	82.9	18.9	5	18.9	5
Caudal	1.5	2	1	2	1
Rib	100	22.1	6	0	0
Scapula	31.6	20	5.5	20	5.5
Prox. Humerus	31.6	6.7	1.5	0	0
Dist. Humerus	25.1	33.3	7.5	33.3	7.5
Prox. Radius	16.5	86.67	16.5	6.7	1.5
Distal Radius	12.1	60	13.5	13.3	3.5
Internal carpal	6.6	73.3	15.5	73.3	15.5
Prox. metacarpal	3.9	40	8.5	6.7	1.5
Dist. metacarpal	2.6	26.7	6.5	26.7	6.5
Innominate	54.7	26.7	6.5	0	0
Prox. femur	69.4	73.3	15.5	0	0
Dist. Femur	69.4	26.7	6.5	0	0
Prox. Tibia	40.8	26.7	6.5	0	0
Dist. Tibia	25.5	93.3	17.5	26.7	6.5
Tarsal C+4	13.6	100	18.5	100	17.5
Prox. Metatarsal	7.5	26.7	6.5	0	0
Dist. Metatarsal	4.5	6.7	1.5	0	0

Table 2. Emerson's (S)MAVGTP index and %MAU based on landmarks and %MAU based on complete elements for occupation two.

Occupation two		Landmarks		Complete	
Element	(S)MAVGTP Value	%MAU	%MAU Rank	%MAU	%MAU Rank
Cranium	14.2	68.8	14.5	68.8	15.5
Atlas	6.4	12.5	5.5	12.5	5.5
Axis	7.8	25	7.5	25	7.5
Cervical	56.6	7.1	4	7.1	4
Thoracic	84.7	3.9	3	3.9	3
Lumbar	82.9	7.3	5	7.3	5
Caudal	1.5	2.5	2	2.5	2
Rib	100	1.4	1	1.4	1
Scapula	31.6	12.5	5.5	12.5	5.5
Prox. Humerus	31.6	12.5	5.5	6.3	3.5
Dist. Humerus	25.1	18.8	6.5	18.8	6.5
Prox. Radius	16.5	37.5	9.5	25	7.5
Distal Radius	12.1	0	0	0	0
Internal carpal	6.6	56.3	12.5	56.3	12.5
Prox. metacarpal	3.9	31.3	8.5	0	0
Dist. metacarpal	2.6	12.5	5.5	6.3	3.5
Innominate	54.7	31.3	8.5	31.3	8.5
Prox. femur	69.4	6.3	3.5	6.3	3.5
Dist. Femur	69.4	6.3	3.5	0	0
Prox. Tibia	40.8	0	0	0	0
Dist. Tibia	25.5	93.8	16	50	12.5
Lateral malleolus	13.6	100	17	100	17.5
Prox. Metatarsal	7.5	12.5	5.5	12.5	5.5
Dist. Metatarsal	4.5	0	0	0	0

Table 3. Emerson's (S)MAVGGRE index and %MAU based on landmarks and %MAU based on complete elements for occupation one.

Occupation one		Landmarks		Complete	
Element	(S)MAVGGRE Value	%MAU	%MAU Rank	%MAU	%MAU Rank
Scapula	43.6	20	5.5	20	5.5
Prox. Humerus	71.8	6.7	1.5	0	1.5
Dist. Humerus	58.5	33.3	7.5	33.3	7.5
Prox. Radius	51.9	86.67	16.5	6.7	16.5
Distal Radius	48.5	60	13.5	13.3	13.5
Internal carpal	38.2	73.3	15.5	73.3	15.5
Prox. metacarpal	33	40	8.5	6.7	8.5
Dist. metacarpal	30.4	26.7	6.5	26.7	6.5
Innominate	97.6	26.7	6.5	0	6.5
Prox. femur	100	73.3	15.5	0	15.5
Dist. Femur	100	26.7	6.5	0	6.5
Prox. Tibia	71.7	26.7	6.5	0	6.5
Dist. Tibia	56.9	93.3	17.5	26.7	17.5
Tarsal C+4	49.6	100	18.5	100	18.5
Prox. Metatarsal	38.9	26.7	6.5	0	6.5
Dist. Metatarsal	33.5	6.7	1.5	0	1.5

Table 4. Emerson's (S)MAVGGRE index and %MAU based on landmarks and %MAU based on complete elements for occupation two.

Occupation two		Landmarks		Complete	
Element	(S)MAVGGRE Value	%MAU	%MAU Rank	%MAU	%MAU Rank
Scapula	43.6	12.5	5.5	12.5	5.5
Prox. Humerus	71.8	12.5	5.5	6.3	3.5
Dist. Humerus	58.5	18.8	6.5	18.8	6.5
Prox. Radius	51.9	37.5	9.5	25	7.5
Distal Radius	48.5	0	0	0	0
Internal carpal	38.2	56.3	12.5	56.3	12.5
Prox. metacarpal	33	31.3	8.5	0	0
Dist. metacarpal	30.4	12.5	5.5	6.3	3.5
Innominate	97.6	31.3	8.5	31.3	8.5
Prox. femur	100	6.3	3.5	6.3	3.5
Dist. Femur	100	6.3	3.5	0	0
Prox. Tibia	71.7	0	0	0	0
Dist. Tibia	56.9	93.8	16	50	11.5
Lateral malleolus	49.6	100	17	100	17
Prox. Metatarsal	38.9	12.5	5.5	12.5	5.5
Dist. Metatarsal	33.5	0	0	0	0

Table 5. Brink and Dawe's Revised Grease Index and %MAU based on landmarks and %MAU based on complete elements for occupation one.

Occupation one		Landmarks		Complete	
Element	Grease index Value	%MAU	%MAU Rank	%MAU	%MAU Rank
Prox. Humerus	241.48	6.7	1.5	0	1.5
Dist. Humerus	64.12	33.3	7.5	33.3	7.5
Prox. Radius	42.71	86.67	16.5	6.7	16.5
Distal Radius	49.73	60	13.5	13.3	13.5
Prox. metacarpal	6.76	40	8.5	6.7	8.5
Dist. metacarpal	14.58	26.7	6.5	26.7	6.5
Prox. femur	112.41	73.3	15.5	0	15.5
Dist. Femur	186.3	26.7	6.5	0	6.5
Prox. Tibia	96.82	26.7	6.5	0	6.5
Dist. Tibia	12.22	93.3	17.5	26.7	17.5
Prox. Metatarsal	7.44	26.7	6.5	0	6.5
Dist. Metatarsal	20.07	6.7	1.5	0	1.5

Table 6. Brink and Dawe's Revised Grease Index and %MAU based on landmarks and %MAU based on complete elements for occupation two.

Occupation two		Landmarks		Complete	
Element	Grease index Value	%MAU	%MAU Rank	%MAU	%MAU Rank
Prox. Humerus	241.48	12.5	5.5	6.3	3.5
Dist. Humerus	64.12	18.8	6.5	18.8	6.5
Prox. Radius	42.71	37.5	9.5	25	7.5
Distal Radius	49.73	0	0	0	0
Prox. metacarpal	6.76	31.3	8.5	0	0
Dist. metacarpal	14.58	12.5	5.5	6.3	3.5
Prox. femur	112.41	6.3	3.5	6.3	3.5
Dist. Femur	186.3	6.3	3.5	0	0
Prox. Tibia	96.82	0	0	0	0
Dist. Tibia	12.22	93.8	16	50	11.5
Prox. Metatarsal	7.44	12.5	5.5	12.5	5.5
Dist. Metatarsal	20.07	0	0	0	0

Table 7. Emerson's (S)MAVGMAR index and %MAU based on landmarks and %MAU based on complete elements for occupation one

Occupation one		Landmarks		Complete	
Element	(S)MAVGMAR Value	%MAU	%MAU Rank	%MAU	%MAU Rank
Scapula	36.9	20	5.5	20	5.5
Prox. Humerus	71.5	6.7	1.5	0	1.5
Dist. Humerus	69.2	33.3	7.5	33.3	7.5
Prox. Radius	68	86.67	16.5	6.7	16.5
Distal Radius	50.3	60	13.5	13.3	13.5
Internal carpal	36.2	73.3	15.5	73.3	15.5
Prox. metacarpal	29.2	40	8.5	6.7	8.5
Dist. metacarpal	18.2	26.7	6.5	26.7	6.5
Innominate	10.2	26.7	6.5	0	6.5
Prox. femur	97.2	73.3	15.5	0	15.5
Dist. Femur	98.2	26.7	6.5	0	6.5
Prox. Tibia	100	26.7	6.5	0	6.5
Dist. Tibia	84.5	93.3	17.5	26.7	17.5
Tarsal C+4	55.2	100	18.5	100	18.5
Prox. Metatarsal	40.6	26.7	6.5	0	6.5
Dist. Metatarsal	25.2	6.7	1.5	0	1.5

Table 8. Emerson's (S)MAVGMAR index and %MAU based on landmarks and %MAU based on complete elements for occupation one

Occupation two		Landmarks		Complete	
Element	(S)MAVGMAR Value	%MAU	%MAU Rank	%MAU	%MAU Rank
Scapula	36.9	12.5	5.5	12.5	5.5
Prox. Humerus	71.5	12.5	5.5	6.3	3.5
Dist. Humerus	69.2	18.8	6.5	18.8	6.5
Prox. Radius	68	37.5	9.5	25	7.5
Distal Radius	50.3	0	0	0	0
Internal carpal	36.2	56.3	12.5	56.3	12.5
Prox. metacarpal	29.2	31.3	8.5	0	0
Dist. metacarpal	18.2	12.5	5.5	6.3	3.5
Innominate	10.2	31.3	8.5	31.3	8.5
Prox. femur	97.2	6.3	3.5	6.3	3.5
Dist. Femur	98.2	6.3	3.5	0	0
Prox. Tibia	100	0	0	0	0
Dist. Tibia	84.5	93.8	16	50	11.5
Lateral malleolus	55.2	100	17	100	17
Prox. Metatarsal	40.6	12.5	5.5	12.5	5.5
Dist. Metatarsal	25.2	0	0	0	0

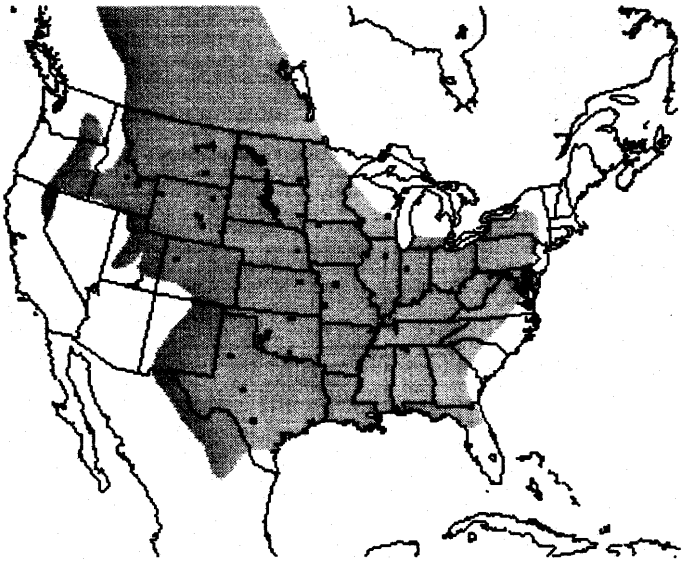
Table 9. Brink and Dawe's Bone Utility Index (BUI) and %MAU based on landmarks and %MAU based on complete elements for occupation one.

Occupation one		Landmarks	Complete
Element	BUI Values	%MAU	%MAU
Prox. Humerus	241.48	6.7	0
Humerus shaft	110.8	53.3	0
Dist. Humerus	64.12	33.3	33.3
Prox. Radius	42.71	86.67	6.7
Radius shaft	82.71	33.3	0
Distal Radius	49.73	60	13.3
Prox. metacarpal	6.76	40	6.7
Metacarpal shaft	19.07	26.7	0
Dist. metacarpal	14.58	26.7	26.7
Prox. femur	112.41	73.3	0
Femur shaft	142.43	26.7	0
Dist. Femur	186.3	26.7	0
Prox. Tibia	96.82	26.7	0
Tibia shaft	122.11	46.7	0
Dist. Tibia	12.22	93.3	26.7
Prox. Metatarsal	7.44	26.7	0
Metatarsal shaft	34.92	13.3	0
Dist. Metatarsal	20.07	6.7	0

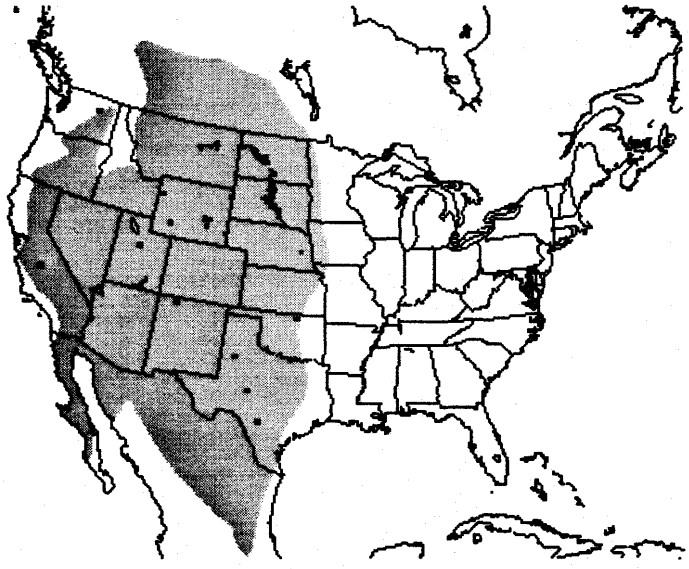
Table 10. Brink and Dawe's Bone Utility Index (BUI) and %MAU based on landmarks and %MAU based on complete elements for occupation two.

Occupation two		Landmarks	Complete
Element	BUI Value	%MAU	%MAU
Prox. Humerus	241.48	12.5	6.3
Humerus shaft	110.8	56.3	0
Dist. Humerus	64.12	18.8	18.8
Prox. Radius	42.71	37.5	25
Radius shaft	82.71	12.5	0
Distal Radius	49.73	0	0
Prox. metacarpal	6.76	31.3	0
Metacarpal shaft	19.07	12.5	0
Dist. metacarpal	14.58	12.5	6.3
Prox. femur	112.41	6.3	6.3
Femur shaft	142.43	56.3	0
Dist. Femur	186.3	6.3	0
Prox. Tibia	96.82	0	0
Tibia shaft	122.11	62.5	0
Dist. Tibia	12.22	93.8	50
Prox. Metatarsal	7.44	12.5	12.5
Metatarsal shaft	34.92	18.8	0
Dist. Metatarsal	20.07	0	0

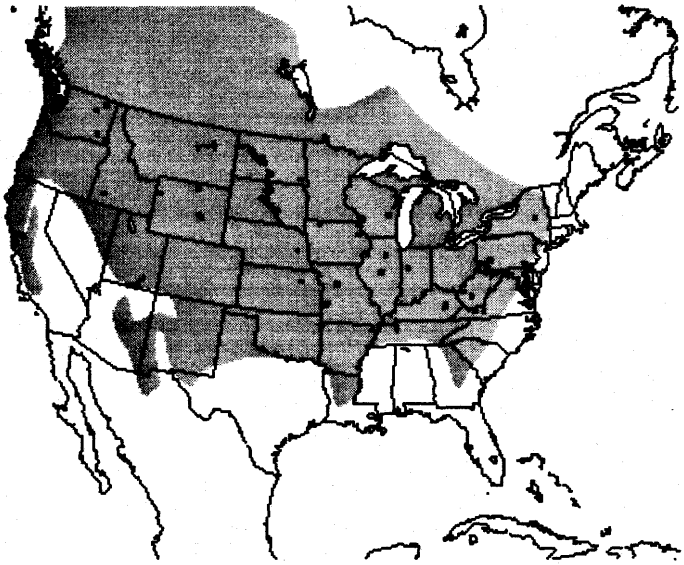
Appendix V: Faunal distribution for Post-Contact Period



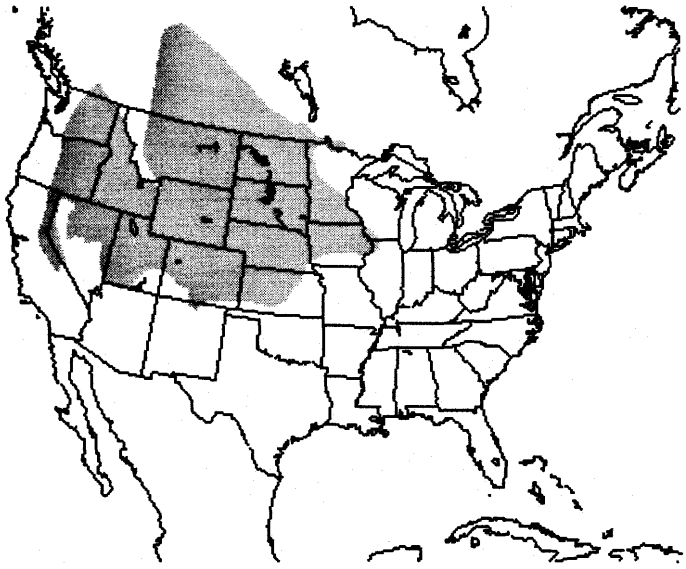
Age= HIST Taxon= Blbi
N= 80
Figure 1. *Bison bison* distribution



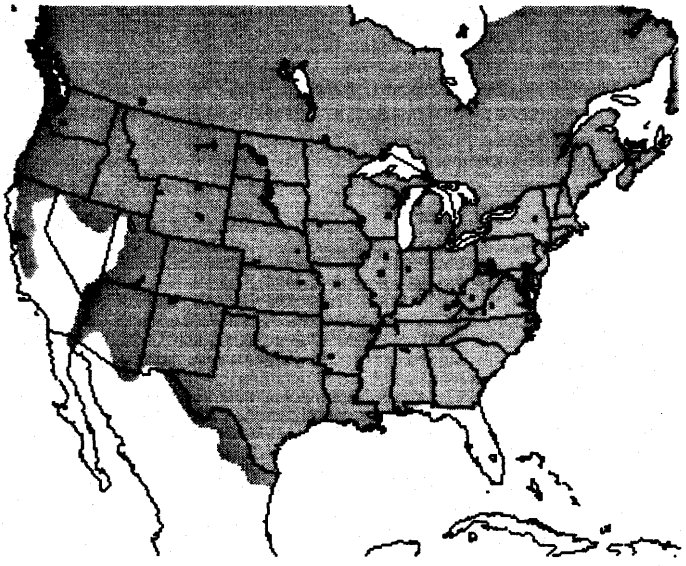
Age= HIST Taxon= ACam
N= 49
Figure 2. *Antilocapra americana* distribution



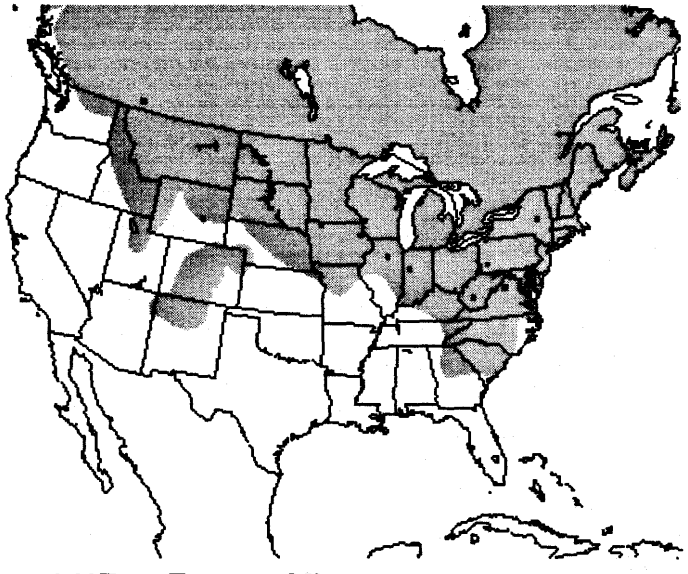
Age= HIST Taxon= CVca
N= 89
Figure 3. *Cervus elaphus* distribution



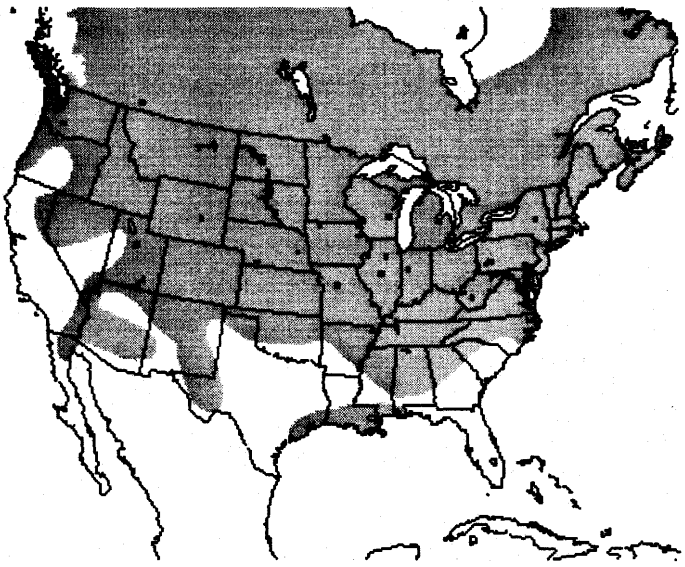
Age= HIST Taxon= LSti
N= 20
Figure 4. *Lepus townsendii* distribution



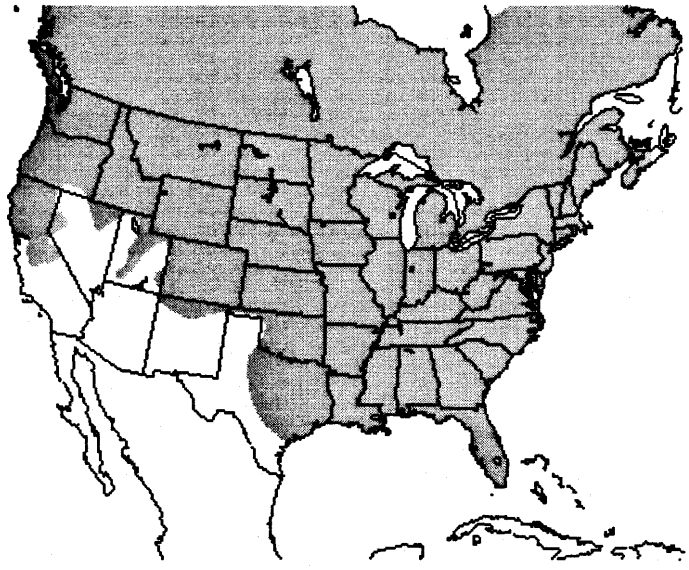
Age= HIST Taxon= CRca
N= 91
Figure 5. *Castor canadensis* distribution



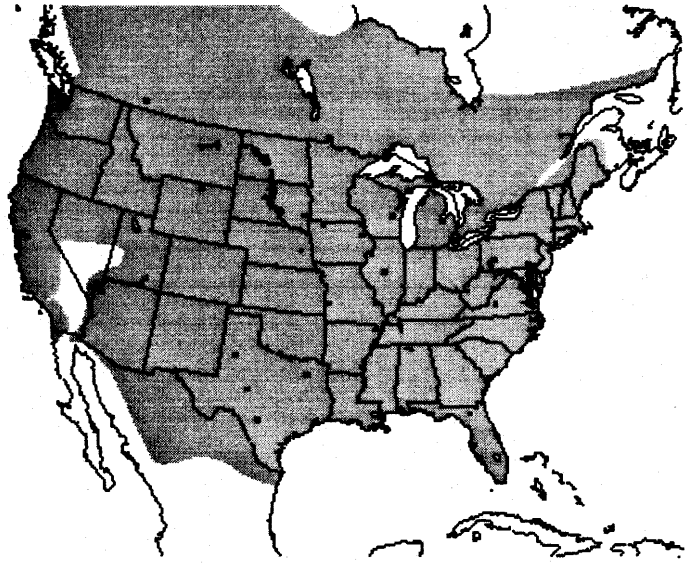
Age= HIST Taxon= MIpe
N= 26
Figure 6. *Microtus pennsylvanicus* distribution



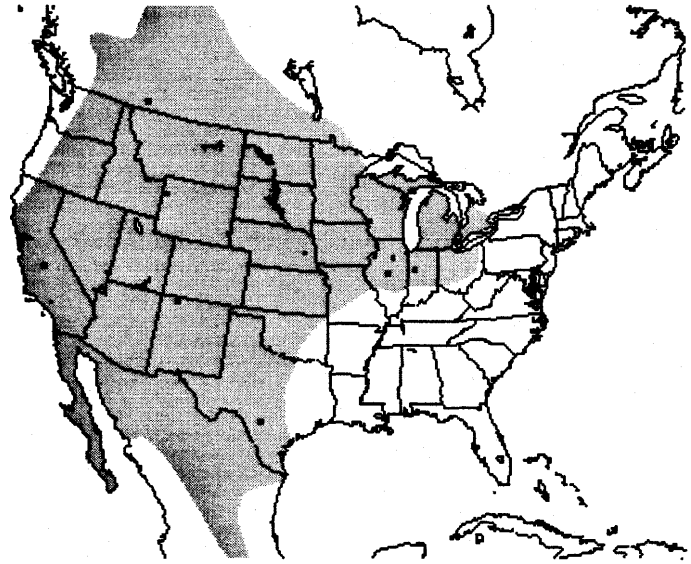
Age= HIST Taxon= OTzi
N= 52
Figure 7. *Ondatra zibethicus* distribution



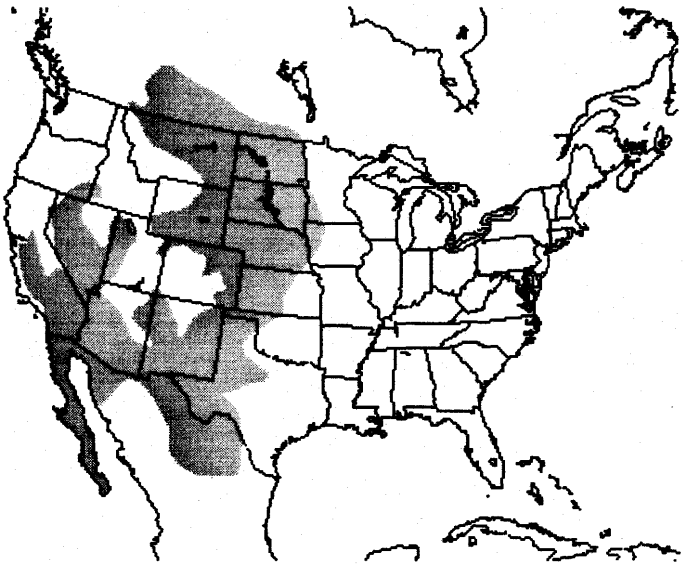
Age= HIST Taxon= MUvi
N= 22
Figure 8. *Mustela vison* distribution



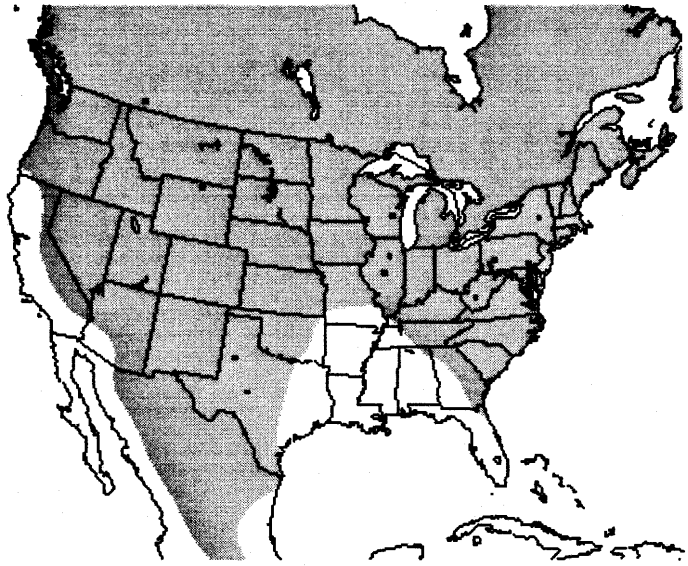
Age= HIST Taxon= MEme
N= 47
Figure 9. *Mephitis mephitis* distribution



Age= HIST Taxon= TXta
N= 44
Figure 10. *Taxidea taxus* distribution



Age= HIST Taxon= VUve
N= 28
Figure 11. *Vulpes velox* distribution



Age= HIST Taxon= CAlu
N= 30
Figure 12. *Canis lupus* distribution

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